WL-TR-96-2014

ADVANCED TURBINE AEROTHERMAL RESEARCH RIG (ATARR) SAFETY AND OPERATING PLAN OVERVIEW

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OCTOBER 1992

FINAL

Approved for public release; distribution unlimited

AERO PROPULSION & POWER DIRECTORATE
WRIGHT LABORATORY
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THE TECHNICAL REPORT HAS BEEN REVIEWED AND IS APPROVED FOR PUBLICATION.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
Oct 92

3. REPORT TYPE AND DATES COVERED
Final

4. TITLE AND SUBTITLE
Advanced Turbine Aerothermal Research Rig (ATARR) Safety and Operating Plan Overview

5. FUNDING NUMBERS
C: F33615-88-C-2825
PE: 62203F
PR: 3066
TA: 06
WU: 84

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Aero Propulsion & Power Directorate
Wright Laboratory
Air Force Materiel Command
Wright Patterson AFB OH 45433-7251
POC: Lt Christian Randell, WL/POTT, 513-255-3150

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
WL-TR-96-2014

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
Attached you will find two notebooks, one is the "ATARR Safety and Operating Plan Overview" by Calspan and the other is the "ATARR Preliminary Safety Report" by Belcan. Together, we believe these two documents cover your safety concerns and your desire for an overview of ATARR operating procedures. The Belcan manual is organized around the PI&D drawings. Every item which occurs on a PI&D drawing is analyzed for safety concerns and manufacturer's safety information is presented. The Calspan manual is designed to provide an overview of the operation of the facility.

14. SUBJECT TERMS
Safety

15. NUMBER OF PAGES
52

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

Table of Contents

1. Report Organization

1.1 Document Goals

The purpose of this document is to provide an overview of the important safety information and operating procedures for the facility. A companion document is the original Belcan "Preliminary Safety Report" which contains much more specific safety information. After a brief introduction, specific safety concerns are discussed based on the PI&D diagrams. Thus if one wants specific information about a tank or valve, one needs only to note which PI&D drawing it is on and go to that section of the safety report. This overview tries to avoid repeating the information presented in the Belcan report, and it does not discuss the data acquisition system (DAS) or the instrumentation. Neither of these systems represent a significant safety threat and thus a full description of them would complicate this document beyond the point of usefulness. This document does not discuss, in detail, the construction and operation of the key components: the main valve, the isolation valve and the eddy brake. Sufficient information on these systems is presented to provide a basis for discussing the safety implications, but it is assumed that the reader will use other reports for the detailed mechanical information about these systems. Nor does this document discuss standard technical practices of how to isolate electrical problems, test for vacuum or pressure integrity, etc. It is written so that a person with standard mechanical/electrical skills can comprehend the basic operation of the facility (but not necessarily how to operate it) and the various situations that can arise which could lead to safety problems.

The document is divided into several sections. This section describes the goals of the report and how to update procedures. The second section focuses on general procedures and problems. In addition to reviewing the operation of the facility, general hazards are grouped and discussed by how fast the hazards can be generated. These problems lead to specific conditions which have set procedures about isolating and rectifying the problem. These are discussed in section III. To aid in these discussions, and to make the manual complete without having to refer to other manuals, section IV has several different diagrams. The first are the as supplied PI&D diagrams from Belcan Corp (there are large ones in the "Preliminary Safety Report". These consist of 5 pages and contain a great deal of information about the overall operation of the system. A second, simplified schematic of just the nitrogen and vacuum systems is also supplied. In addition, the PI&D diagrams (Calspan) for the main valve actuation system, its operation sequence, and a simplified electrical plan are also supplied. The final section contains checklists which can aid the test engineer in setting up an overall test-operation checklist. These are grouped by subsystems since they may be used in different ways for different tests. It will always be the responsibility of the operating person to assure that his checklist represents the real test configuration.

Note: The ATARR is a research facility and is not a turn-key facility. Its configurations and needs will change on a regular basis. Checklists are not insurance policies against having problems. The system is designed to prevent a person from accidentally creating a condition which could be dangerous to oneself or the facility, but it will not prevent one from making serious blunders which expose instrumentation to damage or prevent the facility from running smoothly. That can only be accomplished by having an understanding of the detailed operations of the facility components, which are described in other manuals. Thus creating these checklists should be a verification of ones understanding of the facility and its operation, not a substitute for it.

1.2 How To Use/Update This Document

It should be clear by now that this document is meant to be concise and deal only with safety issues. Keeping this document up to date, reflecting additions to the facility or changes in operation is critical. At the back of the document there is a soft copy of the text, written on an Apple Macintosh based system with Microsoft word. Most any word processor should be able to access this information. As new systems come on-line their PI&D diagrams should be added. In addition, general checklists should also be added. But for this document to be effective it should be kept relatively short and free from information specific to any one turbine test.

1.3 General Definitions Used in Report

Throughout this report the words "facility", "system", "component", and "laboratory floor" are used often. However, there may be times when the items or places that these words refer to may not be clear. To avoid problems before they start we have decided to specify exactly what we mean when these words are used (most of the time).

Facility- Refers either to the entire test stand (i.e. supply tanks, test section, dump tanks, nitrogen supply, vacuum system, etc), or the entire complex, including the vault area and control room (the differences should be apparent from usage)

System- The facility is composed of several systems such as the main valve, isolation valve, instrumentation, DAS, MCS, etc.

Component (or Subsystem)- Some of the systems have specific components. An example is the main valve which has a piston gas supply component and an actuator control component. In general components get named or created when problems start to occur and they get traced to one part of the system.

Laboratory Area (or Bay area)- This refers specifically to the part of the building where the ATARR sits. It does not include the vault area or the control rooms.

2. General Facility Description, Procedures and Problems

ATARR safety issues can best be described by examining the basic construction of the facility and discussing the fundamental operation of the main systems and their individual components. This information naturally leads to the general problems which can arise from the operation of the facility. Procedures for dealing with specific hazards are dealt with in section III.

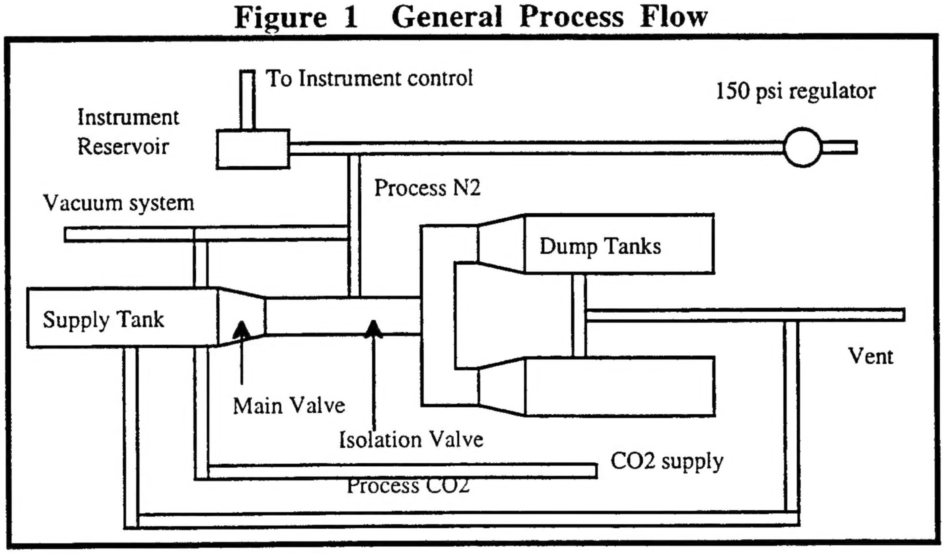
2.1 General Facility Safety Systems

The laboratory and control area (Bld 71B, J-Bay) is equipped with several emergency exists. Two exist on either side of the bay doors, there is one off the control room, there is the main door and there is a tunnel which connects the hall outside of J-bay with the contractor area two bays down. In addition, the laboratory area has low oxygen sensors. If at any time these sensors measure low oxygen, the large doors (at either end of the laboratory) immediately rise and the fire alarm activates, notifying the base fire department personnel who are the only ones allowed to shut-off the alarm. There are also several fire alarm pull stations located around the building and there is at least one movable flammable liquids cabinet. All hazardous material used in J-Bay are coded and are listed in the main control sheet attached to the doors separating the laboratory from the main hall.

2.2 General Gas Flow and Valve Operation in ATARR

In general, the ATARR facility consists of three tanks (1 supply and 2 dump) and a test section which is isolated from the tanks by two large, specially built valves (the main valve and the isolation valve, see figure 1).

Figure 1 General Process Flow



There are provisions for other components such as a cooling system but since they are not yet operational, they are not shown. The facility is operated by pressurizing the supply tank (and/or heating it) and evacuating the test section and dump tank so that the turbine can be spun up to speed

using an electric motor. The main valve is opened and the turbine extracts work from the flow as the test gas passes through the stage. To prevent the turbine speed from increasing during the test, an eddy brake extracts the power, thereby maintaining a relatively constant turbine speed. The power extracted by the eddy brake goes into heating the eddy-brake drum. The test time is generally limited by the maximum temperature at which the drum can maintain safe structural integrity. Under normal working conditions only about a third of the gas in the supply tank is used, since the eddy brake limits the test time. The isolation valve serves three main purposes. First, it allows the test section to be isolated from the dump tank creating the ability to both pressurize and evacuate the test-section independently of the supply and dump tanks. Secondly the isolation valve sets the choke area downstream of the stage, creating the correct pressure drop across the stage. Thirdly, the isolation valve acts as an emergency system shut-down. There is enough energy in the supply tank at its normal working conditions to overspeed many turbines and quickly cause them to burst which could occur if:

1) the main valve failed to close, causing the brake drum to overheat and fail
2) the eddy brake failed during turbine operation
3) the eddy brake was configured wrong or failed to engage

Since all these conditions create a rapid increase in the turbine speed, the isolation valve is designed to close quickly (less then 100 ms) if the speed of the turbine exceeds some preset level.

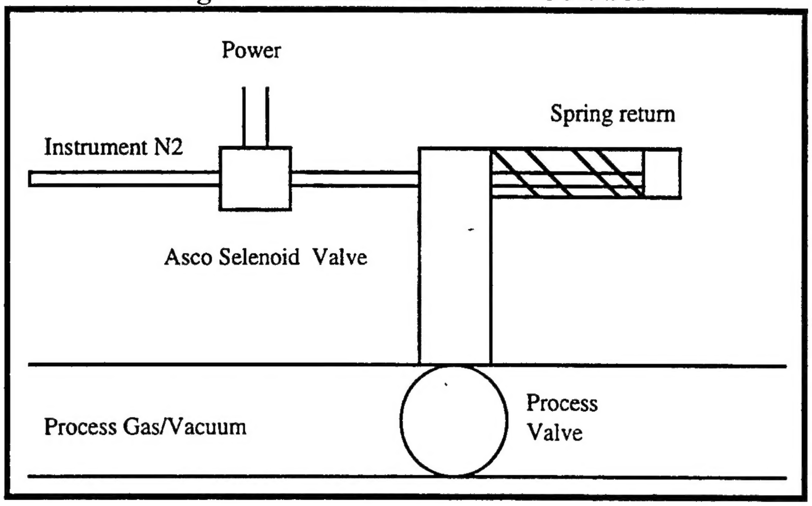
Facility operation requires a source of test gas and a source of vacuum. A mixture of nitrogen (N_2) and carbon dioxide (CO_2) allows a wide range of test conditions (again see figure 1). The nitrogen for the facility (with the exception of the activation gas for the main valve, discussed latter) comes from a tube truck located outside of the facility. A flexible hose connects the tube truck to a permanent pipe which has a pressure regulator preset to 150 psi (see section IV for PI&D's). Thus nitrogen comings from this source into the building can not have a pressure greater than 150 psi (without something failing). The nitrogen entering the building has two uses. The first is to power the valves (instrument reservoir); the other is to fill the supply tank for use as the test gas. The carbon dioxide (CO_2) is only used as a component of the test gas. It is stored as a liquid in dewers along the wall. From there the vapor is extracted and used in the facility.

The vacuum system consists of a Stokes pump, a Roots blower, and a Balston filter. This system is plumbed into the facility to provide the ability to evacuate different parts of the facility either independently, or together. In addition, all the tanks can be vented to atmosphere. Each tank or section of the facility is controlled by the Monitor Control System (MCS).

Most of the valves in ATARR are controlled as shown in figure 2 (notable exceptions are the main valve actuator control component of the main valve system and the isolation valve, discussed latter). The instrument N_2 goes to an actuator valve (usually an Asco valve) on top of the main process valve. This gas is applied to the actuator by use of a small electric solenoid valve

which is an on/off-vent type. When the valve is activated, pressure is applied to the actuator and the process valve opens; when the Asco valve is deactivated (or off) the pressure is vented and a spring return forces the main valve closed.

Figure 2 General Valve Control



2.2.1 The Monitor Control System (MCS)

The MCS has three main tasks. First, it controls the process valves in two different modes. One is a direct command from the user to open or close a specific valve (Exercise Valve Menu, see MCS manuals Vol 1, 2, and 3). In that case, the MCS tells the Asco valve to activate which in turn activates the main process valve. Since both the main control valve and the Asco valves have separate numbers (usually an FVxyy and an EVxyy, respectively, where x stands for the PID sheet and yy is the valve number), the MCS indicates which valve it is controlling by the EVxyy number. Thus it is important to know which electric valve controls which process valve. The second type of process control comes from where the user asks the MCS to do a specific task, such as fill the supply tank to a set pressure (these are the Charge, Vent and Pumpdown Menus). In this case, the MCS goes through pre-programmed logic to make sure that certain valves are set appropriately before the action is allowed to take place. If specific conditions exist, the MCS will give a warning and not proceed. A good example is the evacuating procedure. When one wishes to evacuate the supply tank, the MCS checks to make sure the pressures in the lines are not so high as to damage the vacuum pump. If they are, the MCS will not continue until the supply tank is vented. This decision process is referred to as the control logic and is specified in the MCS manuals.

The second task of the MCS is monitoring and displaying pressures, alarm conditions, etc. Key to controlling the facility is knowing what pressures are in each section of the facility. Pressures can be monitored and displayed on the MCS as well as used for inputs to logic controls. When a pressure goes below or above a preset value, an alarm can be designated to appear on the

MCS. This has been used extensively to keep the user informed as to supply pressure, cooling water pressure, etc.

The final task of the MCS is to control the processes of arming and activating the main valve and eddy brake. Arming each system is similar to the other MCS functions in that the MCS follows a distinct logic pattern to open and close appropriate valves in a set sequence. The fundamental difference comes when the MCS controls the timing of when to start the eddy brake and when to close the main valve. In this process all other functions of the MCS are suspended to maintain a quick response to any problems encountered during a run.

2.3 General Safety Issues

The brief description of the facility outlined above shows how problems could occur. Failure of power to the Asco valve, or low instrument nitrogen pressure could cause the main process valves to close unexpectedly. This has lead to one on the major design philosophies of the ATARR system which is **Fail-Isolate**. If anything fails in the ATARR system, or if an emergency exists, the entire system is designed to close all valves, which isolates all sections of the facility.

There are really three different types of problems that can arise in the facility which have fundamentally different time constants. The first set of problems involves the evacuation or filling of the various tanks and sections in the ATARR facility and have the longest time constants since these process usually take tens of minutes to complete. These are all governed by the process controls outlined above and failure generally consists of the facility not filling when it is supposed to, or not evacuating when it should. This, while annoying, is not a safety issue, since the tanks all have emergency reliefs on them (thus they can not be over-pressurized and the reliefs are ducted to the outside), and the flow from the high pressure tanks outside is metered down to 150 psi with the flow restricted. In addition there are many manual ways (i.e. independent of the MCS) to check pressure levels. Failure can also come from a loss of communications from the MCS to the valve or from the MCS reading an inaccurate pressure. In the first case, the controllers of the valves can be set so that in the event of lost communications they either return to the last state of the valve, or they default to a preset position (either open or close). For this facility, all valves have been set to fail close, thus from any failure (short of a mechanical valve failure) they close. The last potential problem is for the MCS to read a pressure inaccurately. This occurs when the pressure transducers drift. This is only a problem when the facility has to be vented. The pressure transducers are absolute sensors and have been found to be accurate to about ±2 psi. Thus one can vent the facility using the vent command (which opens the vent valves until the pressure reads 1 atmosphere and then closes the vent valves) and still have some pressure (or vacuum) in the tank. This problem is easily overcome by manually opening the vent lines before servicing the facility.

The second set of problems (with a time constant of seconds) comes from arming the systems which allow the ATARR facility to operate. These would be the main valve, the isolation valve, and the cooling system (when it is installed). These are problems only if the valves have a pressure differential across them and something were to go wrong during the arming sequence which would cause an unexpected valve motion. How critical a situation like this may be is a strong function of the facility configuration. Without the rotor installed, there is little that can happen if the main valve were to open unexpectedly. These situations are avoided by not allowing a pressure differential to exist in the system until one is ready to operate the facility. Examining the three main systems: the main valve, the isolation valve, and the eddy brake can help to illustrate these points.

2.3.1 Main Valve

The run-time operation of the main valve is covered in a separate document (see Main Valve Report for more details), but it can be summarized here for clarity. The complete main valve system consists of a piston supply component, an actuator control component (which controls the piston supply) and a triggering component. Figure 3 shows a simplified schematic of the piston gas supply and figure 4 shows the actuator control component. The main valve is moved using a hydraulic piston . The main valve is held closed by any pressure in the supply tank as long as it is greater than the pressure in the test section. The total area holding the main valve closed is determined by the two o-rings on the valve which create an area of ≈ 77 in^2. While the piston which moves the valve has an area ≈ 40.6 in^2. Thus it takes approximately twice the supply tank to test section pressure difference to make the main valve open[1]. This piston is moved by applying pressure to either the opening or closing sides while having the opposite side vented to atmosphere. The pressures in each chamber of the piston housing can be monitored from the outside through the two pressure instrumentation ports. There are connections for five needle valves (although they do not have to be used) which control the flow going in and out of each chamber. There are two standard Whitey 3-way ball valves attached to special fast acting (30 ms) Calspan manufactured actuators (P1 and P2) which control the gas flow to the piston. The actuator control component shown in figure 4 controls these valves.

Basically the two reservoirs are filled the way Belcan intended them to be. Regulators PCV 107 and PCV 109 (see Belcan PI&D) are used to set the pressures which range between 400-600 psi. P1 and P2 are set such that the piston chambers are connected to the vent (in other words, the gas supply is isolated). Then EV 152 and EV 151 are opened which in turn open PV 114 and PV 101, allowing the two reservoirs to be filled. At any point in time, the manual valves could be

[1] However, when the main valve is closed there is no ΔP acting on the main valve, so any ΔP across the piston should make the main valve move (accounting for friction, of course).

opened to release the gas in the cylinders. Once the cylinders are filled, valves EV 152 and EV 151 are closed, which close PV 114 and PV 101.

The main valve is opened by turning P1 so that the opening reservoir is connected to piston chamber 1 which forces the piston and main valve open. The main valve is closed by turning P1 such that the piston chamber 1 is connected to vent and P2 such that the closing reservoir is connected to piston chamber 2.

This component has several different features. First, the main valve activation component can be run without any gas in the piston supply which allows the system to be checked out (even if the supply tank is pressurized) before a run without having to open the main valve. Secondly, to fire the main valve requires that both the piston supply and actuator components be armed. Either armed (and fired) independently will not make the valve move. Finally, to make the entire main valve system fail-safe requires only that P2 stay in its chamber 2 to close reservoir mode and that P1 be in a mode which connects chamber 1 to the vent.

There are two types of valves. Valves EV602[2], EV603 and EV603' are 3-way fast -acting Marrota valves. Valves EV603 and 603' are operated together (i.e. there are no independent controls, hence their names). All the electric valves are AC actuated Whitey ball valves. EV 601 and 605 are on-off valves while EV 604 and 606 are three way valves. There is a needle valve (NV607) which meters the flow into the actuator system and a regulator which sets the maximum pressure. Each position on the Whitey valves has a terminal. When power is applied to the terminal, the valve rotates to that position, stops and turns off the power. To move the valve to the next position requires that power be applied to the appropriate terminal. This is beneficial since 1) once the valve is in the proper position no current is drawn, reducing the E-M noise in the environment and 2) if there is a power failure the valves stay in their last state. The key valves which move P1 and P2 are the Marotta's. The system is armed by activating valves 3 and 3'. This blocks the reservoir and connects P1b and P2a to atmosphere. The test starts when EV602 is activated, forcing P1 to change position and releasing gas from the open reservoir into chamber 1 (see figure 3). The test terminates when the main valve is closed and is accomplished by deactivating EV 602, 603 and 603' (which happens much faster than activation). This basically causes P1 and P2 to change positions. As an extra safety precaution, the power for EV602 comes from EV603 such that there is activation power when EV603 is energized. Thus if one were to make a mistake and fire EV602 without any gas in the activation reservoir, or without the intention

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2 The numbering system has changed. All other PI&D valve references on ATARR are referenced to the original Belcan nomenclature where every valve, flow control device was labeled according to the following system "**abcxyy**" where abc refers to the type of flow control device. EV is electric valve, PSV is pressure safety valve, etc. X refers to the PI&D sheet number and yy refers to the actual number. When the main valve was undergoing initial testing, the valves were simply numbered 1,2,3, etc. which correspond to the present last two digits of the existing numbering system. Thus older editions will refer to these valves simply by their number with no other references noted.

of closing the main valve, it could not be done. One first has to arm EV603 and EV603'. Once this has been accomplished, any power failures or problems automatically deactivates all valves which forces gas into chamber 2, closing the main valve if it is open, or holding it close if it has not opened.

Summary: During an actual test (when gas if flowing through a turbine stage) a power loss immediately shuts the main valve. Before a test, but after the system has been armed, a power loss ensures that main valve remains closed.

2.3.2 Isolation Valve

During the initial check out of this system it became clear that the present operation of the isolation valve was unacceptable. Therefore the existing valve will be redesigned and the present isolation valve operating procedure will be changed. This system is not required for the vane-only tests, but will be needed for the full stage testing. An update to this document will be provided after final check-out of the modified valve.

2.3.3 Eddy Brake

The present operating procedure as designed by Belcan is currently being checked-out. It is clear that some addition computer (MCS) checks are needed to verify proper brake profiles. Final testing can not be accomplished until the entire brake system is installed in ATARR, sometime in November. An update to this document will be provided after final check-out.

The final source of problems could be developed during a run and would occur rapidly (with a time constant less than 100 ms). The time scale is so small that human intervention can not be counted on, so the isolation valve is designed to shut down the test in the event of either of the following: 1) the main valve failed to close at the appropriate time or 2) the eddy brake failed to turn on or failed during operation. In both cases, the tachometer mounted on the shaft would sense an overspeed condition and close the isolation valve quickly so as to prevent disk rupture.

2.3.4 Emergency Shut-Down Procedure

The emergency shut-down procedure is completely dependent on the final configurations of the isolation valve and the eddy-brake. As noted above, the isolation valve is currently being redesigned and the eddy brake is not yet fully installed. For the purposes of the immediate demonstration experiments (non-rotating, vane only there is no emergency situation. This section will added just prior to full-stage demonstration experiments.

2.4 General Operation

2.4.1 Non-Rotating Experiments

It should be clear at this point that there are relatively few operating dangers associated with running the facility in this configuration since there are no rotating components. Thus if the main valve were to open unexpectedly, all that would happen is that gas would blow through the vane row before one wanted to do so. Dangers in this mode of operation occur from operator blunders

such as not insuring that all the test section pieces are bolted together properly, by forgetting to secure the housing ports, or by working internal on the test section when the supply tank is pressurized. The probability of something like this happening are greatly reduced by using common sense and by making a pretest walk-around checklist. The major problems are likely to come from the process control of the facility (i.e evacuating and filling the tanks). Specific actions to be taken in case of a problem are outlined in section III.

2.4.2 Rotating Experiments

This section will be added when the final configuration becomes apparent, especially with regard to the isolation valve and eddy brake configuration.

3. Specific Hazard Procedures

This section discusses specific problems which may arise in the ATARR. They are grouped by major activity since a wide variety of testing conditions could cause each problem. The specific actions are outlined here with the assumption that the operator will work backwards towards isolating and rectifying the problem.

3.1 Major N2 Leak

The ATARR facility is equipped with low oxygen sensors which (as mentioned in section II) force the main laboratory doors wide open if there is a significant leak and turn on the fire alarm which can only be reset by the fire department. If this alarm goes off when the tanks are being filled, the procedure should be:

1) Isolate all sections of the facility (i.e. stop filling tanks, stop evacuating tanks, etc.) This can be done by:

a) in the MCS stopping all processes you are engaged in by either telling it to stop or by exiting the menu

b) pushing the big power shut-off switch on the control panel

2) Leave the building

3) Turn-off the tube truck both at the truck and at the manual valve next to the laboratory big door.

Having done the above, no more gas can enter J-Bay and only the gas already in the section which is leaking can continue to leak out. Once the fire department has come and reset the alarm, try to isolate and determine which section of the facility is leaking.

Realistically, this type of situation has only two sources. One comes from leaking a small amount of nitrogen constantly over a long period of time. The alarm was once set off by blowing 150 psi nitrogen through the main valve to get rid of the metal chips. After several hours sufficient nitrogen had accumulated in the laboratory to set off the alarm. The situation could have easily been avoided by simply opening the laboratory doors to allow a breeze to blow through the facility. The second source is if a leak develops while one is filling the supply tank. It is difficult to envision this happening unless the operator was filling from the control room and no one was in J-bay to hear the leak. There is very little problem hearing even small leaks in the system. Thus it makes some sense, especially during the initial tests of any matrix to do the filling from the laboratory floor.

3.2 Fire

In general, the response is the same as for a major N2 leak. The intent is to isolate the facility and leave the building. There is actually not much in the laboratory area that can burn, so the largest probability of a fire comes from either cleaning solvents or electrical problems. If one

knows or suspects that the source of the fire is electrical, then the electrical shut-down procedure should be followed.

3.3 Minor N2 Leak

More likely one will suffer small leaks where the pressure (or vacuum) in a section of the facility can not be held constant. This only becomes a safety problem if the oxygen sensors go off. Most often the individual leaks would be isolated long before there would be a safety concern.

3.4 Liquid CO_2 Filling

Probably the most hazardous routine duty will be working with the liquid CO_2 dewers due to the low temperature. Procedures and equipment for all tasks relating to these dewers are covered extensively in the information package from the manufacture, which is included as an appendix to this report.

3.5 Tank Entry

Entering the supply tank at any point in time when the main valve is in place should be considered a potential hazardous situation (especially when one is entering immediately after testing). The recommended procedure is too "change out" the gas in the supply tank by evacuating the tank and then venting to atmosphere. This works quite well, especially if the vacuum pump filters are working (so that residual vacuum oil vapor is not blown back into the supply tank). An oxygen monitor should then be inserted into the tank to check for oxygen levels before a person enters the tank. Upon entering the tank someone should be on the outside ready to call for help in case there is an emergency.

General procedures:

1) Change gas in tank by evacuating and then venting to atmosphere
2) Check oxygen level with monitor
3) Have a spotter
4) Enter tank

3.6 Vacuum System

The vacuum pump system consist of three parts (as mentioned in section II) the main pump, the filter and the Roots blower. The system can be damaged and thus will not perform correctly if:

1) The filters are cracked or not installed properly, which is indicated by excess smoke. When the vacuum pump and filters are working properly there should be very little smoke coming out of the vents above the side big door.

2) The cooling water is not turned on. The best check for this is to shine a flashlight through the sight-glass from the back. If the cooling water is on, the flapper valve will be open and in a more or less horizontal position.

3) If there is too much or too little oil in the system. There is a sight glass on the side of the pump. Manufactures instructions should be followed.

4) Over-pressurization of the pump or blower occurs.

This last condition is the most likely of the four listed above, and its occurrence shortens the life expectancy of vacuum pumps. The vacuum pump itself can sustain only about 1 to 2 psi above atmosphere (these data are in the stokes pump manual). However the blower is even more sensitive and can not sustain a large pressure differential. It is designed to be used as a booster to aid in lowering the pressure to the one torr range. The controls are set up so that the blower can either come on automatically when the pressure reaches a certain point (about 20 torr), or it can be permanently turned-off. The blower becomes damaged if in the process of evacuating one section of the facility with the blower on, someone inadvertently opens another section of the facility (at high pressure) to be evacuated. In this scenario the blower sees about 1 atmosphere, creating a large strain on the system. The best way to avoid this problem is to keep the blower off until all sections of the facility are connected together and being pumped down together. Then one can turn the blower to automatic.

In general, the MCS prevents one from inadvertently over-pressurizing the vacuum pump by verifying that pressures in all the relevant piping are within limits when one requests to pump down any section of the facility. This of course is true only of the main control menus and is not true of the exercise valve menu, which has no logic associated with it. All of the logical checks done by the MCS are listed in the MCS software manual (release 3).

Thus the checklist for operating the vacuum pump is simply:

1) Turn on and verify cooling water is on
2) Verify oil level is correct
3) Set blower to off
4) Turn on pump

It is important to note that the vacuum pump can be turned off from the control panel upstairs. The vacuum pump button has the effect of disrupting the power to the vacuum system. However to restart the pump requires direct control at the vacuum pump. It was designed so that the vacuum pump could be shut down immediately before the test without having to go down to the laboratory area.

3.7 Test Time Failures

There are basically three types of failures that can occur during testing (i.e. the time from where one begins to fill the tanks to the time at which they are vented). The first two: power and pressure failures, basically cause the system to become isolated. This is desirable if a problem arises, so the system has already gone to its fail-safe position and what remains is to find out why

the problem occurred. These are generally the types of failures that occur over several hours leading up to the turbine test.

During a turbine test (which lasts about 5 seconds), there is only one real concern: that the rotor speeds exceed its safety limits. As mentioned earlier, this can occur due to an eddy brake failure or a main valve failure. The isolation valve is designed to sense this condition, independently of the MCS, and to close within 100 ms. There is nothing the operator can do in a 100 ms interval to influence this event. There is, however, an emergency stop button on the control panel which cuts off power to everything. This, as explained earlier during the isolation valve discussion, will immediately close the isolation valve if there is any pressure across it (the only dangerous condition). However, by the time the operator has figured out what is happening, the system will have already closed the isolation valve.

3.8 Electrical Shut-Down Procedure

This section will be inserted after full testing of the eddy-brake system since the eddy-brake is the main consumer of power in the laboratory area during a test.

3.9 Last Resort Procedure

If there is a problem not understood by the operator, and the traditional fail-isolate procedures have not stabilized the situation, then the following are general guidelines.

1) If the power gets shut-off, you generally will not be able to use the MCS to help diagnose the situation. While there are manual gauges on every tank, reading them requires someone to be on the laboratory floor, which should be done with great caution under these conditions.

2) When power is available but the operator does not understand what is going on, reduce the energy levels (that is all sources), turn off gas (everywhere, at tube truck, manual valves, etc), vent tanks and turn off extraneous power sources. However to vent the system requires the MCS. This can be done either through the vent menu or through the exercise valve menu. The vent menu will use pressure transducers to check to see if it has completely vented (introducing the possibility that there may be transducer error), while the exercise valve menu will keep the vents open until the user closes them.

4. Facility Diagrams

In this section there are four sets of schematics dealing with: the general facility PI&D's, the general nitrogen flow schematic, the main valve actuator operation schematics, and a simplified power schematic.

General PI&D's (pgs. 16 - 21)

These are copies of the original Belcan drawings. The last page is an additional one furnished by Calspan which covers the main valve activation system.

Simplified Nitrogen Flow and Vacuum System (pgs. 22 - 23)

This diagram shows the main plumbing of the facility. It can be used in conjunction with the MCS logic to see how the MCS controls the various facility operations.

Main Valve Schematics (pgs. 24 - 35)

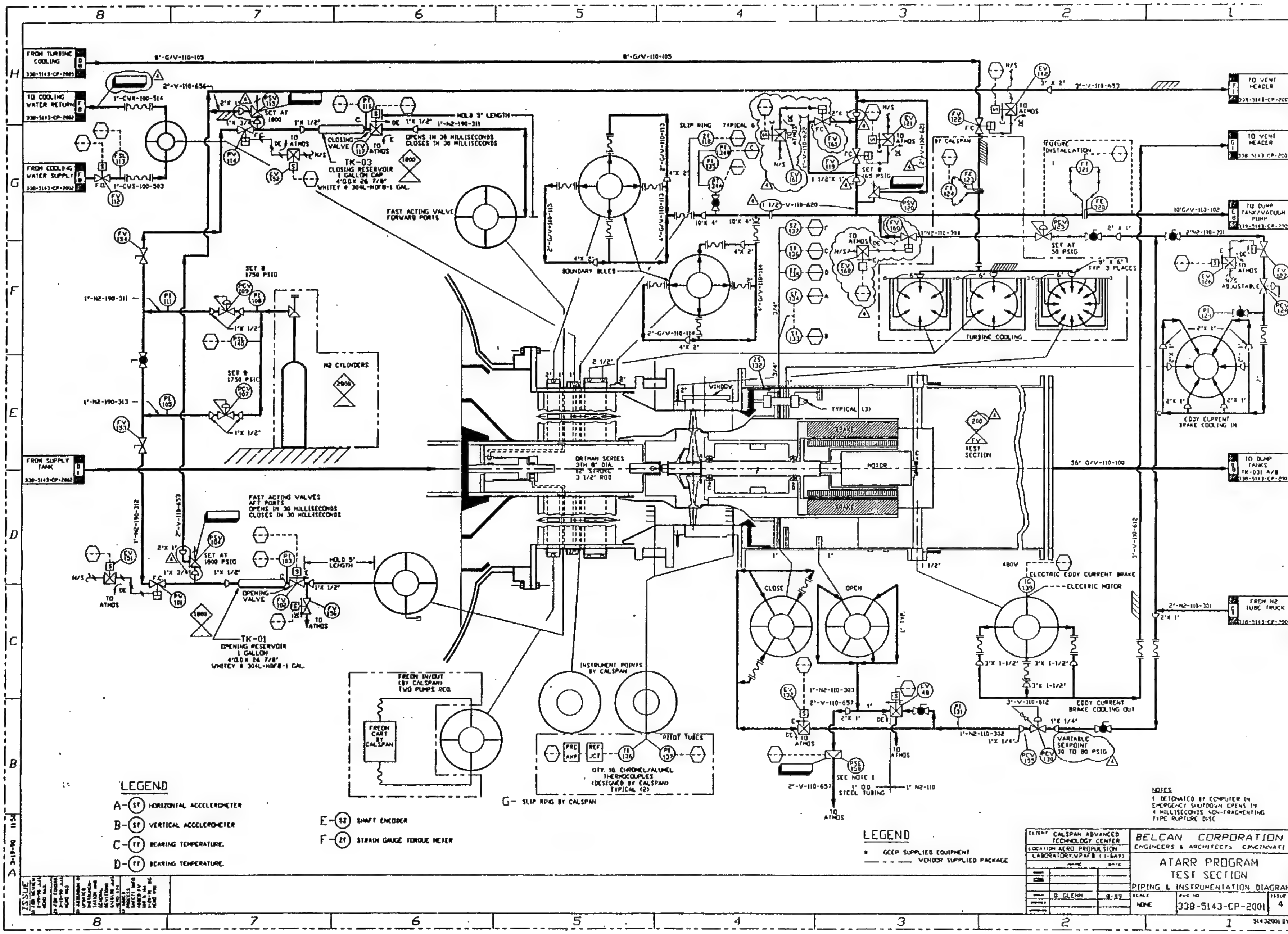
These include the simplified schematics of both the main valve piston gas supply (figure 3) and the main valve activation control (figure 4). In addition the steps used to control the activation system are also described. There is a great deal of information in these schematics.

First, figure 3 shows the main valve piston gas supply from valves PV101 and PV114 through the system. These drawings include the pressure transmitters used for the MCS but not those which are used for instrumentation purposes (which are not permanent). Figure 4 shows a piping schematic of the actuator system. In addition all three way valves have their connections labeled with arrows. For the Whitey valves (EV604 and EV606) there is no default state, while the Marotta valves (EV602, EV603, and EV603') all have default states as labeled. In this drawing the schematics of P1 and P2 show the internal configuration of the spindle. Using this information as a guide, the activation steps show slightly different information. In these drawings each valve position (as described on the right-side of the page) is shown in the piping diagrams, thus showing how the different pieces are connected together. At the bottom of the page the piston gas flow paths are shown by the dark fill lines. Thus in the neutral state, both chambers of the piston are connected to vent. These dark lines show how the piston gas propagates through the main valve (shown in figure 3). An example is shown in step 2 where EV603 and EV603' are activated and EV601 is opened, filling the actuation reservoir (note: to conserve space, only the last digits are used to indicate the valve numbers in the drawing). Also note that in the drawing valve EV603 and EV603' have changed position from the neutral step to Step 1. The lighter fill lines show the leakage path that exists when the actuators P1 and P2 change position. The bottom of each page describes the action taking place.

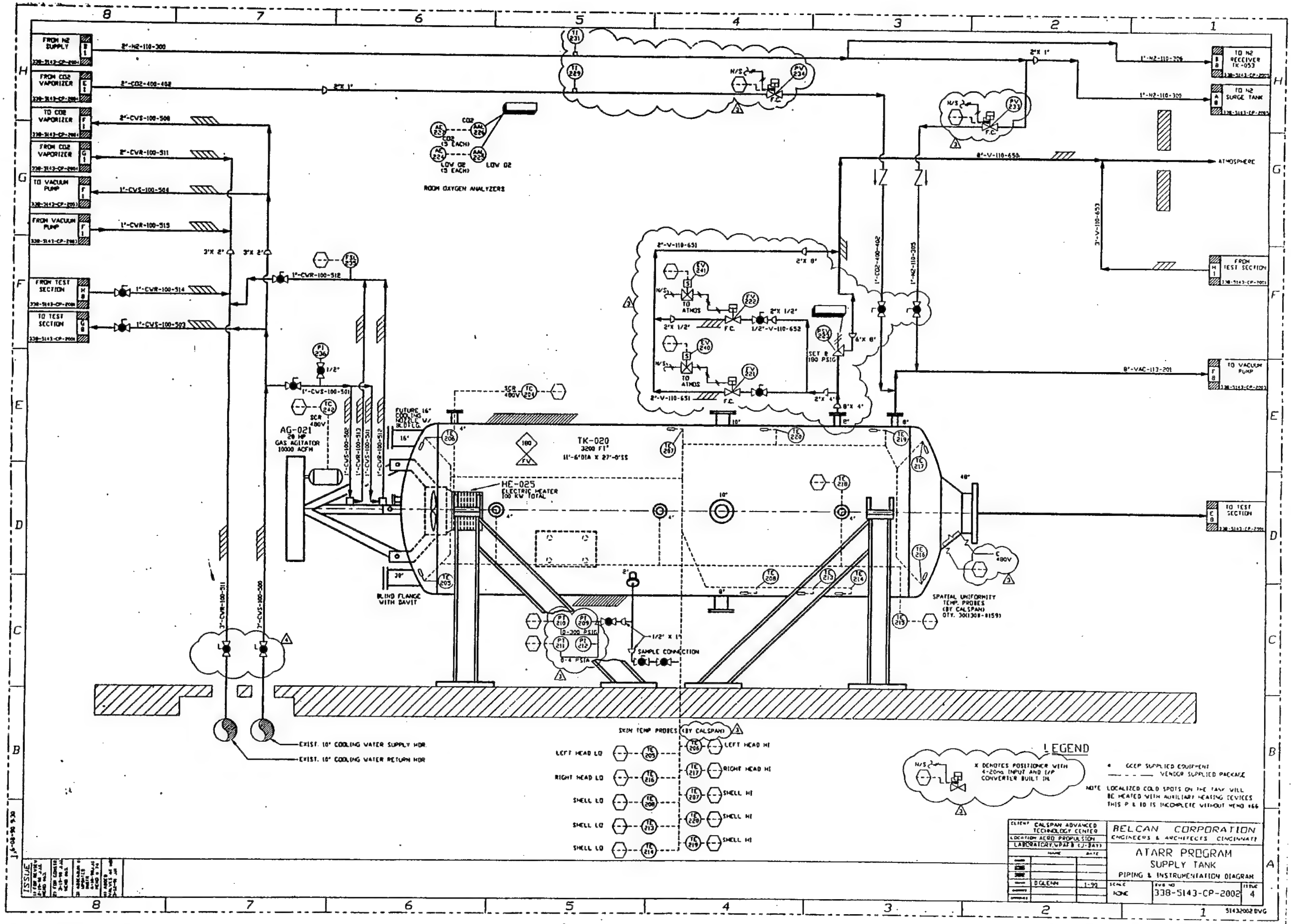
Simplified Electrical System (pg. 36 - 37)

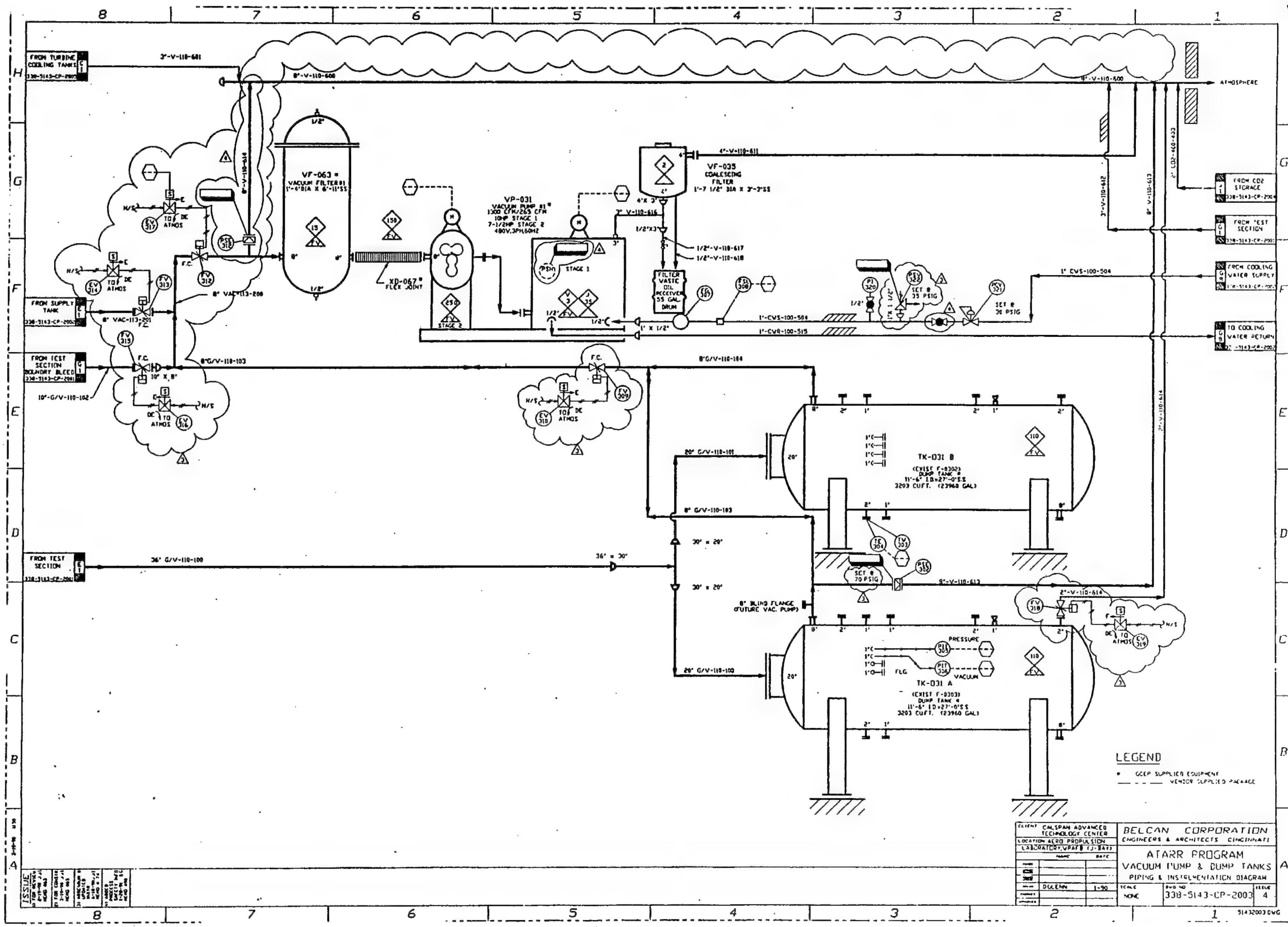
This drawing needs to be added by the ATARR facility to reflect changes made in the Eddy-Brake system.

General PI&D's

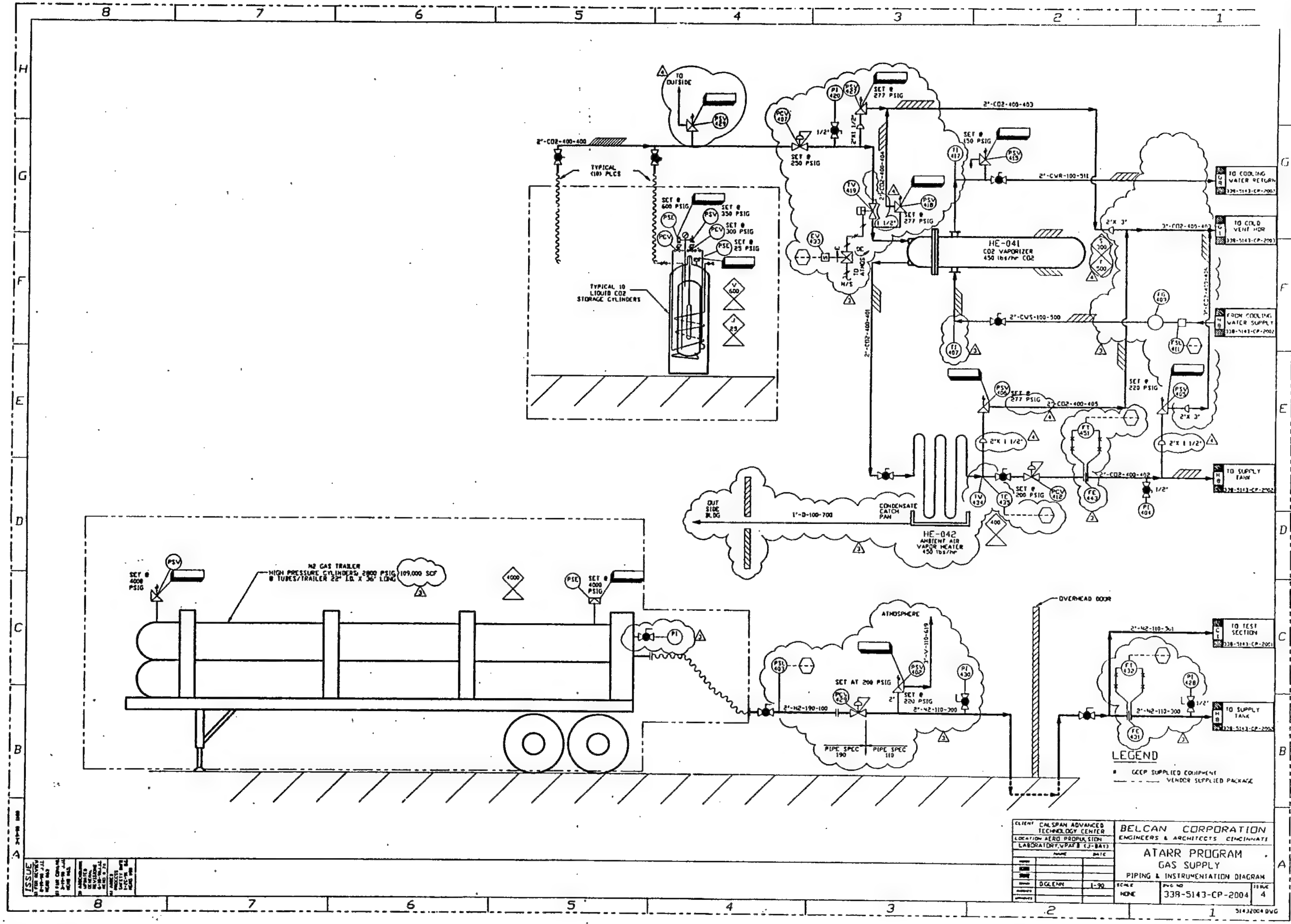


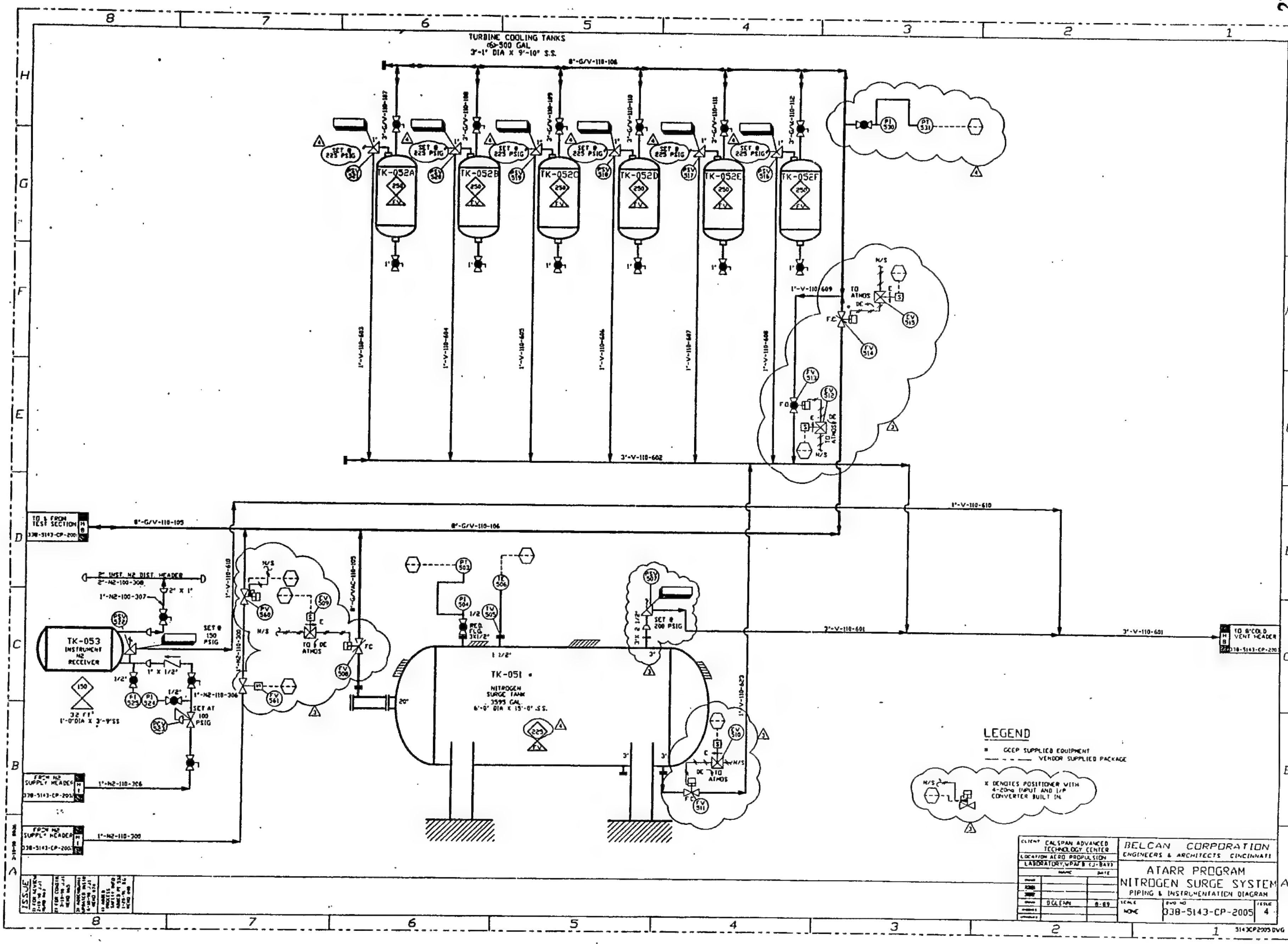
FROM TURBINE COOLING
TO COOLING WATER RETURN
FROM COOLING WATER SUPPLY
FROM SUPPLY TANK
TO VENT HEADER
TO DUMP TANK/VACUUM PUMP
TO DUMP TANKS TK-031 A/B
FROM N2 TUBE TRUCK
8"-G/V-110-105
36" G/V-110-100
TK-03
CLOSING RESERVOIR
1 GALLON CAP
TK-01
OPENING RESERVOIR
1 GALLON
FAST ACTING VALVES FORWARD PORTS
FAST ACTING VALVES AFT PORTS
OPENS IN 30 MILLISECONDS
CLOSES IN 30 MILLISECONDS
N2 CYLINDERS
SET @ 1750 PSIG
SET AT 1800 PSIG
SET AT 50 PSIG
BOUNDARY BLEED
TURBINE COOLING
EDDY CURRENT BRAKE COOLING IN
EDDY CURRENT BRAKE COOLING OUT
ELECTRIC EDDY CURRENT BRAKE
ELECTRIC MOTOR
MOTOR
BRAKE
TEST SECTION
WINDOW
FUTURE INSTALLATION
BY CALSPAN
SLIP RING
INSTRUMENT POINTS BY CALSPAN
PITOT TUBES
QTY. 10 CHROMEL/ALUMEL THERMOCOUPLES (DESIGNED BY CALSPAN) TYPICAL (2)
FREON IN/OUT (BY CALSPAN) TWO PUMPS REQ.
FREON CART BY CALSPAN
VARIABLE SETPOINT 30 TO 80 PSIG
CLOSE
OPEN
LEGEND
A- (ST) HORIZONTAL ACCELEROMETER
B- (ST) VERTICAL ACCELEROMETER
C- (TT) BEARING TEMPERATURE
D- (TT) BEARING TEMPERATURE
E- (SZ) SHAFT ENCODER
F- (ZT) STRAIN GAUGE TORQUE METER
G- SLIP RING BY CALSPAN
LEGEND
GCCP SUPPLIED EQUIPMENT
VENDOR SUPPLIED PACKAGE
NOTES:
1 DETONATED BY COMPUTER IN EMERGENCY SHUTDOWN OPENS IN 4 MILLISECONDS NON-FRAGMENTING TYPE RUPTURE DISC
CALSPAN ADVANCED TECHNOLOGY CENTER
AERO PROPULSION LABORATORY, WPAFB
BELCAN CORPORATION
ENGINEERS & ARCHITECTS CINCINNATI
ATARR PROGRAM
TEST SECTION
PIPING & INSTRUMENTATION DIAGRAM
D. GLENN
8-89
NONE
338-5143-CP-2001
4


FROM N2 SUPPLY
FROM CO2 VAPORIZER
TO CO2 VAPORIZER
FROM CO2 VAPORIZER
TO VACUUM PUMP
FROM VACUUM PUMP
FROM TEST SECTION
TO TEST SECTION
TO N2 RECEIVER TK-053
TO N2 SURGE TANK
ATMOSPHERE
FROM TEST SECTION
TO VACUUM PUMP
TO TEST SECTION
ROOM OXYGEN ANALYZERS
TK-020
3200 FT³
11'-6"DIA X 27'-0"SS
HE-025
ELECTRIC HEATER
AG-021
GAS AGITATOR
10000 ACFM
BLIND FLANGE WITH DAVIT
SAMPLE CONNECTION
SPATIAL UNIFORMITY TEMP. PROBES (BY CALSPAN)
SKIN TEMP PROBES (BY CALSPAN)
LEFT HEAD LO
RIGHT HEAD LO
SHELL LO
LEFT HEAD HI
RIGHT HEAD HI
SHELL HI
EXIST. 10" COOLING WATER SUPPLY HDR.
EXIST. 10" COOLING WATER RETURN HDR
LEGEND
X DENOTES POSITIONER WITH 4-20mA INPUT AND I/P CONVERTER BUILT IN.
GCEP SUPPLIED EQUIPMENT
VENDOR SUPPLIED PACKAGE
NOTE LOCALIZED COLD SPOTS ON THE TANK WILL BE HEATED WITH AUXILIARY HEATING DEVICES
THIS P & ID IS INCOMPLETE WITHOUT MEMO
CALSPAN ADVANCED TECHNOLOGY CENTER
AERO PROPULSION LABORATORY, WPAFB
BELCAN CORPORATION
ENGINEERS & ARCHITECTS CINCINNATI
ATARR PROGRAM
SUPPLY TANK
PIPING & INSTRUMENTATION DIAGRAM
338-5143-CP-2002
ISSUE

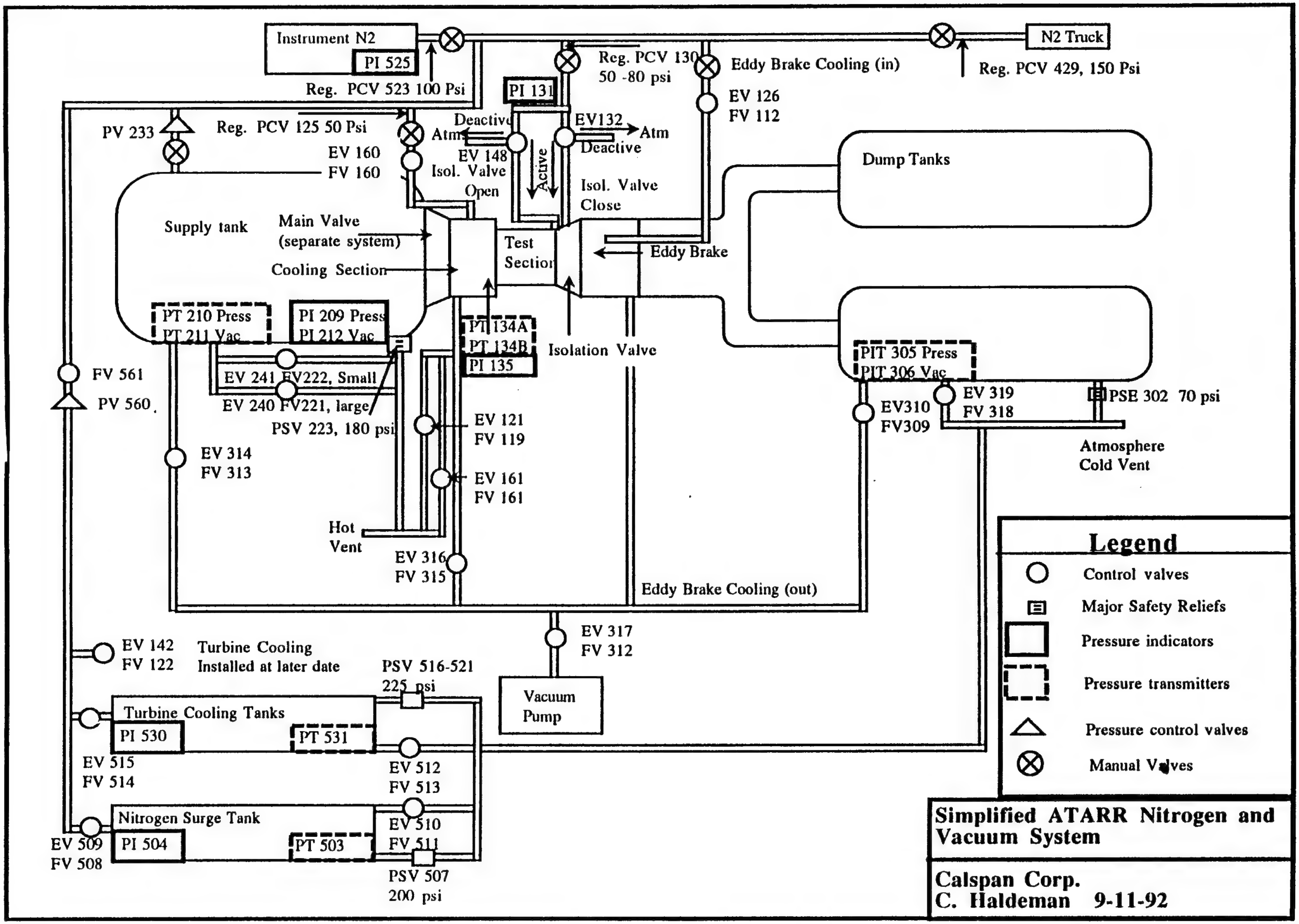


FROM TURBINE COOLING TANKS
3"-V-110-601
8"-V-110-600
ATMOSPHERE
VF-063 = VACUUM FILTER #1 1'-6"DIA X 6'-11"SS
XD-067" FLEX JOINT
VP-031 VACUUM PUMP #1" 1300 CFM/265 CFM 10HP STAGE 1 7-1/2HP STAGE 2 480V,3PH,60HZ
STAGE 1
STAGE 2
VF-035 COALESCING FILTER 1'-7 1/2" DIA X 3'-3"SS
FILTER WASTE OIL RECEIVER 55 GAL. DRUM
FROM CO2 STORAGE
FROM TEST SECTION
FROM COOLING WATER SUPPLY
TO COOLING WATER RETURN
1" CWS-100-504
1"-CWS-100-504
1"-CWR-100-515
FROM SUPPLY TANK
8" VAC-113-201
8" VAC-113-200
FROM TEST SECTION BOUNDRY BLEED
10"-G/V-110-102
8"G/V-110-103
8"G/V-110-104
FROM TEST SECTION
36" G/V-110-100
36" x 30"
30" x 20"
20" G/V-110-101
8" G/V-110-103
20" G/V-110-100
8" BLIND FLANGE (FUTURE VAC. PUMP)
TK-031 B (EXIST F-0302) DUMP TANK # 11'-6" I.D.x27'-0"SS 3203 CU.FT. (23960 GAL.)
TK-031 A (EXIST F-0303) DUMP TANK # 11'-6" I.D.x27'-0"SS 3203 CU.FT. (23960 GAL.)
PRESSURE
VACUUM
SET @ 70 PSIG
SET @ 35 PSIG
SET @ 20 PSIG
8"-V-110-613
2"-V-110-614
LEGEND
GCEP SUPPLIED EQUIPMENT
VENDOR SUPPLIED PACKAGE
CLIENT CALSPAN ADVANCED TECHNOLOGY CENTER
LOCATION AERO PROPULSION LABORATORY, WPAFB
BELCAN CORPORATION
ENGINEERS & ARCHITECTS CINCINNATI
ATARR PROGRAM
VACUUM PUMP & DUMP TANKS
PIPING & INSTRUMENTATION DIAGRAM
SCALE NONE
338-5143-CP-2003
ISSUE 4
ISSUE


TO OUTSIDE
TYPICAL (10) PLCS
TYPICAL 10 LIQUID CO2 STORAGE CYLINDERS
HE-041
CO2 VAPORIZER
450 lbs/hr CO2
TO COOLING WATER RETURN
TO COLD VENT HDR
FROM COOLING WATER SUPPLY
TO SUPPLY TANK
CONDENSATE CATCH PAN
HE-042
AMBIENT AIR VAPOR HEATER
450 lbs/hr
OUT SIDE BLDG
N2 GAS TRAILER
HIGH PRESSURE CYLINDERS, 2800 PSIG
8 TUBES/TRAILER 22" I.D. X 36' LONG
109,000 SCF
ATMOSPHERE
SET AT 200 PSIG
PIPE SPEC 190
PIPE SPEC 110
OVERHEAD DOOR
TO TEST SECTION
TO SUPPLY TANK
LEGEND
GCEP SUPPLIED EQUIPMENT
VENDOR SUPPLIED PACKAGE
CLIENT CALSPAN ADVANCED TECHNOLOGY CENTER
LOCATION AERO PROPULSION LABORATORY, VPAF B (J-BAY)
BELCAN CORPORATION
ENGINEERS & ARCHITECTS CINCINNATI
ATARR PROGRAM
GAS SUPPLY
PIPING & INSTRUMENTATION DIAGRAM
33R-5143-CP-2004
ISSUE


TURBINE COOLING TANKS
(6)-500 GAL
3'-1" DIA X 9'-10" S.S.
TK-052A
TK-052B
TK-052C
TK-052D
TK-052E
TK-052F
SET @ 225 PSIG
8"-G/V-110-106
3"-V-110-602
1"-V-110-610
8"-G/V-110-105
TO & FROM TEST SECTION
2" INST. N2 DIST HEADER
TK-053
INSTRUMENT N2 RECEIVER
SET @ 150 PSIG
SET AT 100 PSIG
FROM N2 SUPPLY HEADER
TK-051
NITROGEN SURGE TANK
3595 GAL
6'-0" DIA X 15'-0" S.S.
SET @ 200 PSIG
3"-V-110-601
TO B'COLD VENT HEADER
LEGEND
* GCEP SUPPLIED EQUIPMENT
VENDOR SUPPLIED PACKAGE
X DENOTES POSITIONER WITH 4-20mA INPUT AND I/P CONVERTER BUILT IN.
CLIENT CALSPAN ADVANCED TECHNOLOGY CENTER
LOCATION AERO PROPULSION LABORATORY, WPAFB (J-BAY)
BELCAN CORPORATION
ENGINEERS & ARCHITECTS CINCINNATI
ATARR PROGRAM
NITROGEN SURGE SYSTEM
PIPING & INSTRUMENTATION DIAGRAM
038-5143-CP-2005
ISSUE

Simplified Nitrogen Flow and Vacuum System



Instrument N2
PI 525
Reg. PCV 523 100 Psi
N2 Truck
Reg. PCV 429, 150 Psi
Reg. PCV 130
50 -80 psi
Eddy Brake Cooling (in)
EV 126
FV 112
PI 131
PV 233
Reg. PCV 125 50 Psi
Deactive
Atm
EV 148
Isol. Valve
Open
EV132
Atm
Deactive
Active
Isol. Valve
Close
EV 160
FV 160
Dump Tanks
Supply tank
Main Valve
(separate system)
Cooling Section
Test
Section
Eddy Brake
PT 210 Press
PT 211 Vac
PI 209 Press
PI 212 Vac
PT 134A
PT 134B
PI 135
Isolation Valve
PIT 305 Press
PIT 306 Vac
FV 561
PV 560
EV 241 EV222, Small
EV 240 FV221, large
PSV 223, 180 psi
EV 121
FV 119
EV 319
FV 318
PSE 302 70 psi
EV310
FV309
Atmosphere
Cold Vent
EV 314
FV 313
EV 161
FV 161
Hot
Vent
EV 316
FV 315
Eddy Brake Cooling (out)
EV 317
FV 312
EV 142
FV 122
Turbine Cooling
Installed at later date
PSV 516-521
225 psi
Vacuum
Pump
Turbine Cooling Tanks
PI 530
PT 531
EV 515
FV 514
EV 512
FV 513
Nitrogen Surge Tank
PI 504
PT 503
EV 510
FV 511
EV 509
FV 508
PSV 507
200 psi
Legend
Control valves
Major Safety Reliefs
Pressure indicators
Pressure transmitters
Pressure control valves
Manual Valves
Simplified ATARR Nitrogen and Vacuum System
Calspan Corp.
C. Haldeman 9-11-92

Main Valve Schematics

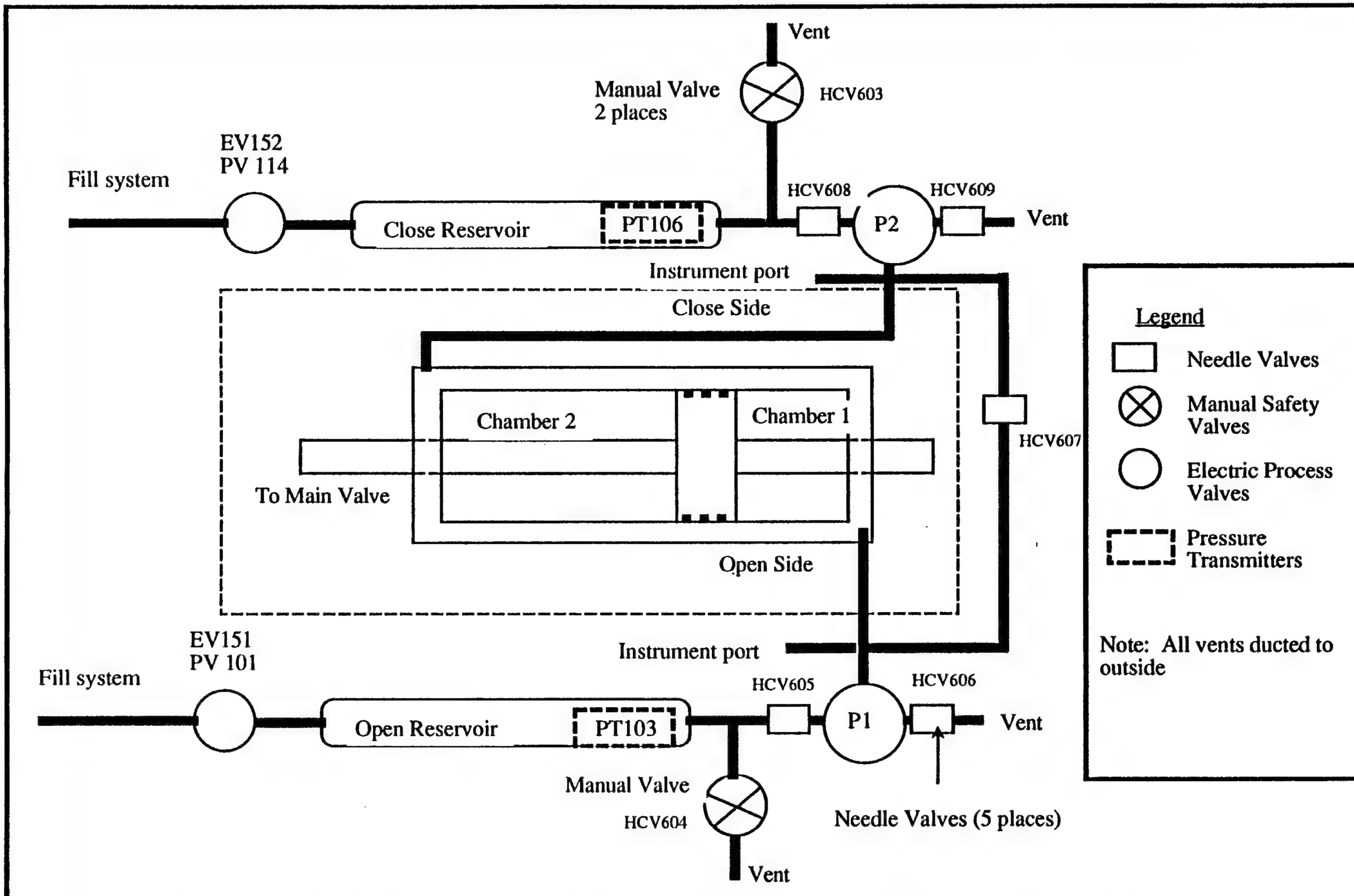
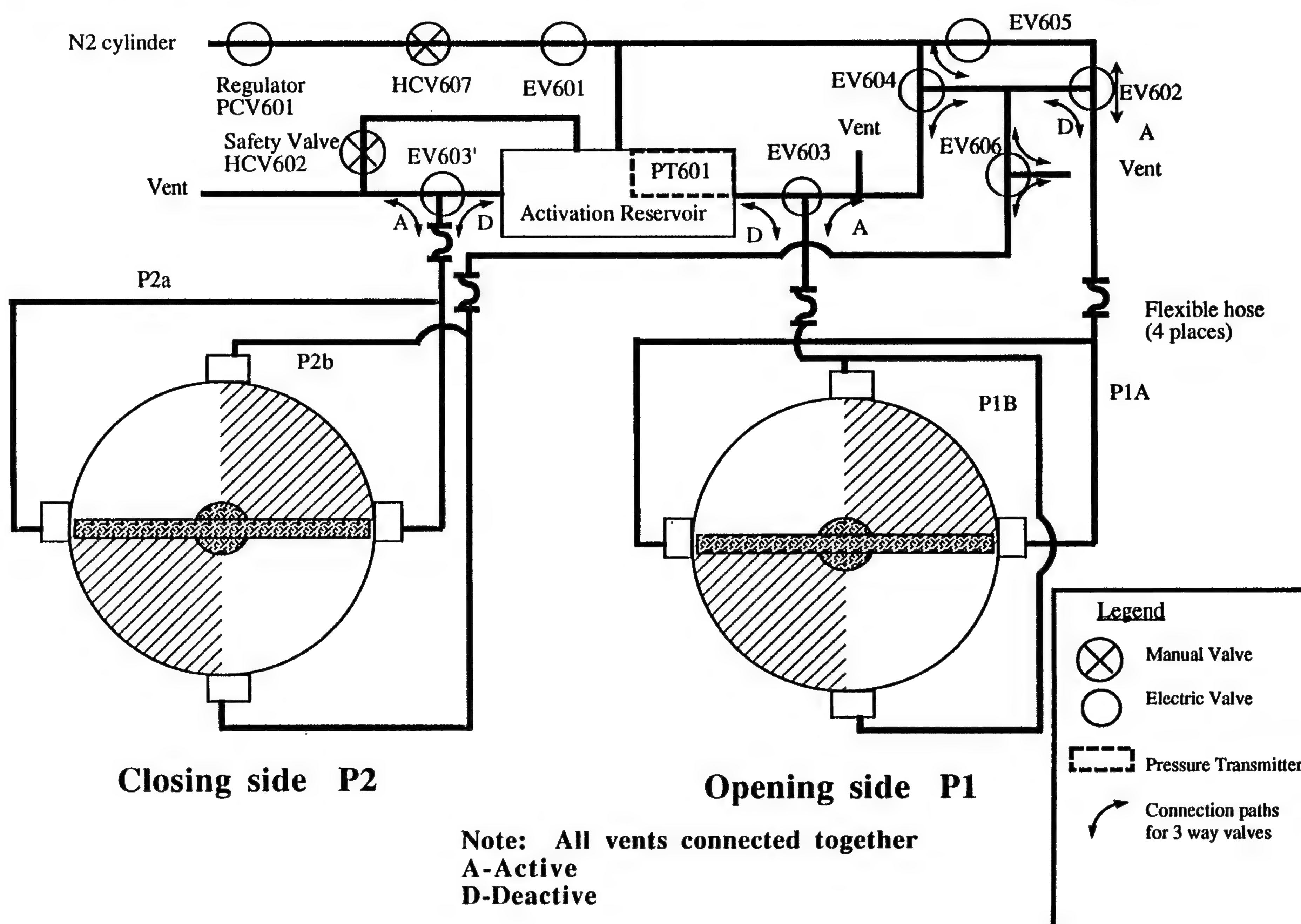
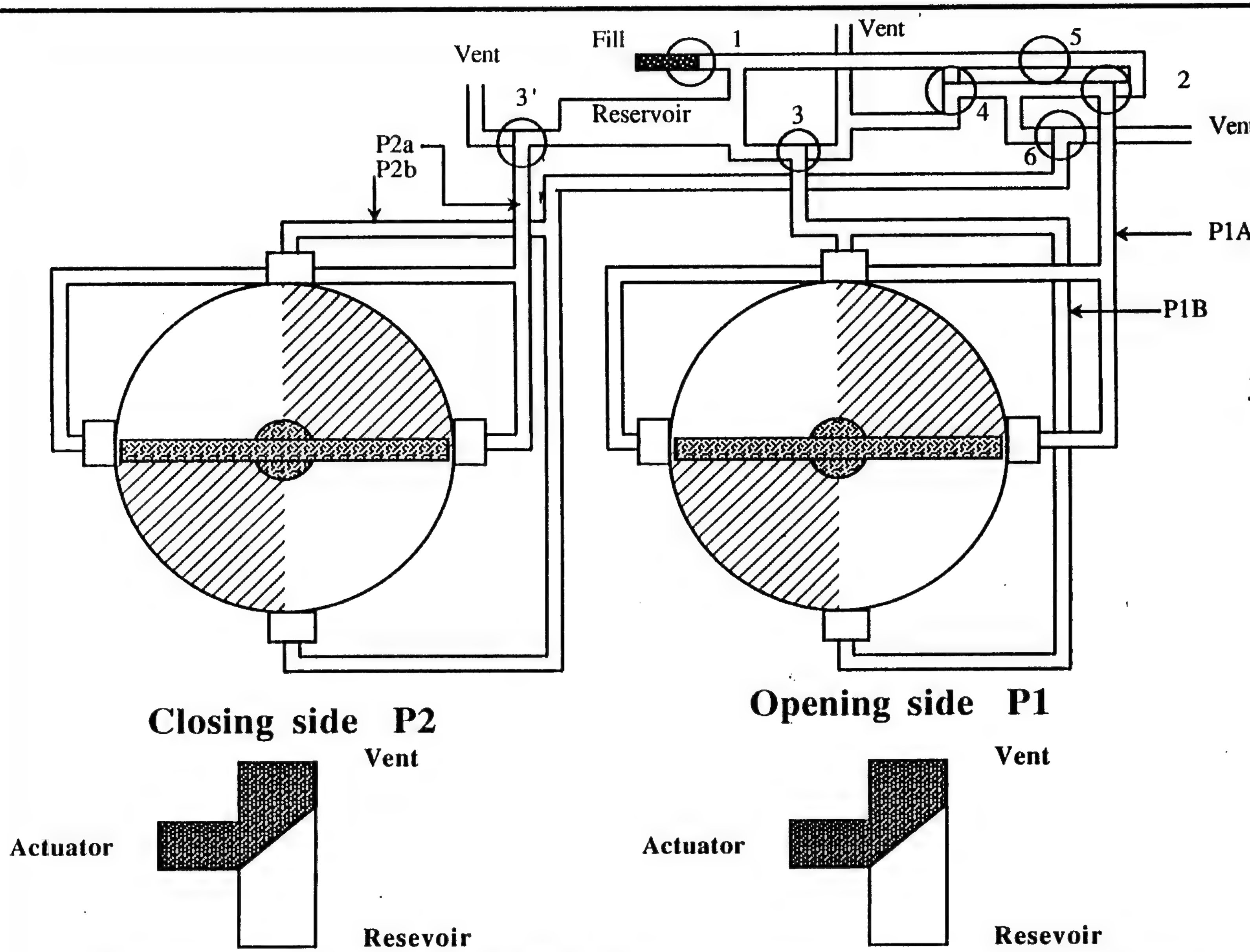


Figure 3 Simplified Schematic of Main Valve Piston Gas Supply

Figure 4 Schematic of Main Valve Actuator Control



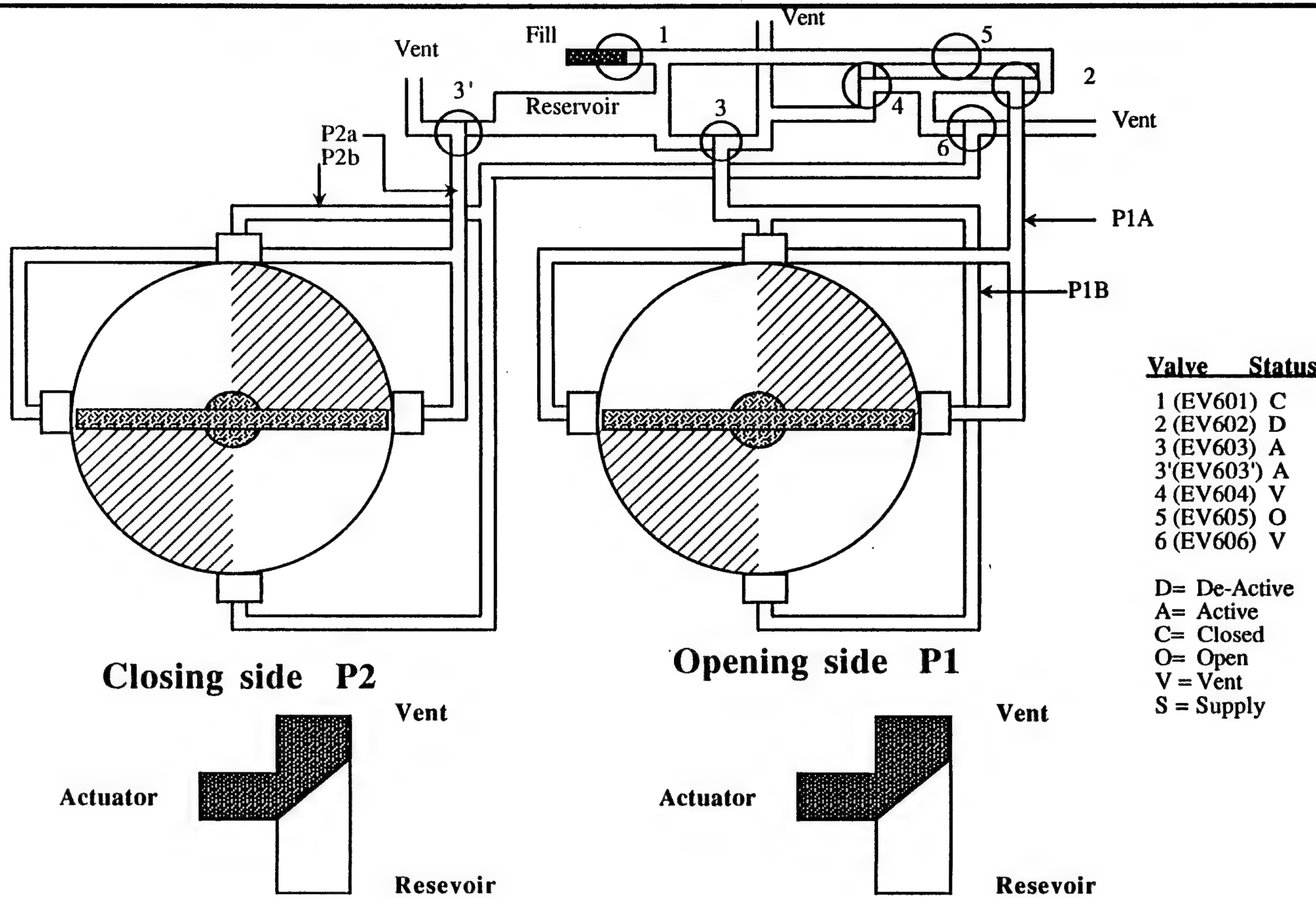
Note: All vents connected together
A-Active
D-Deactive



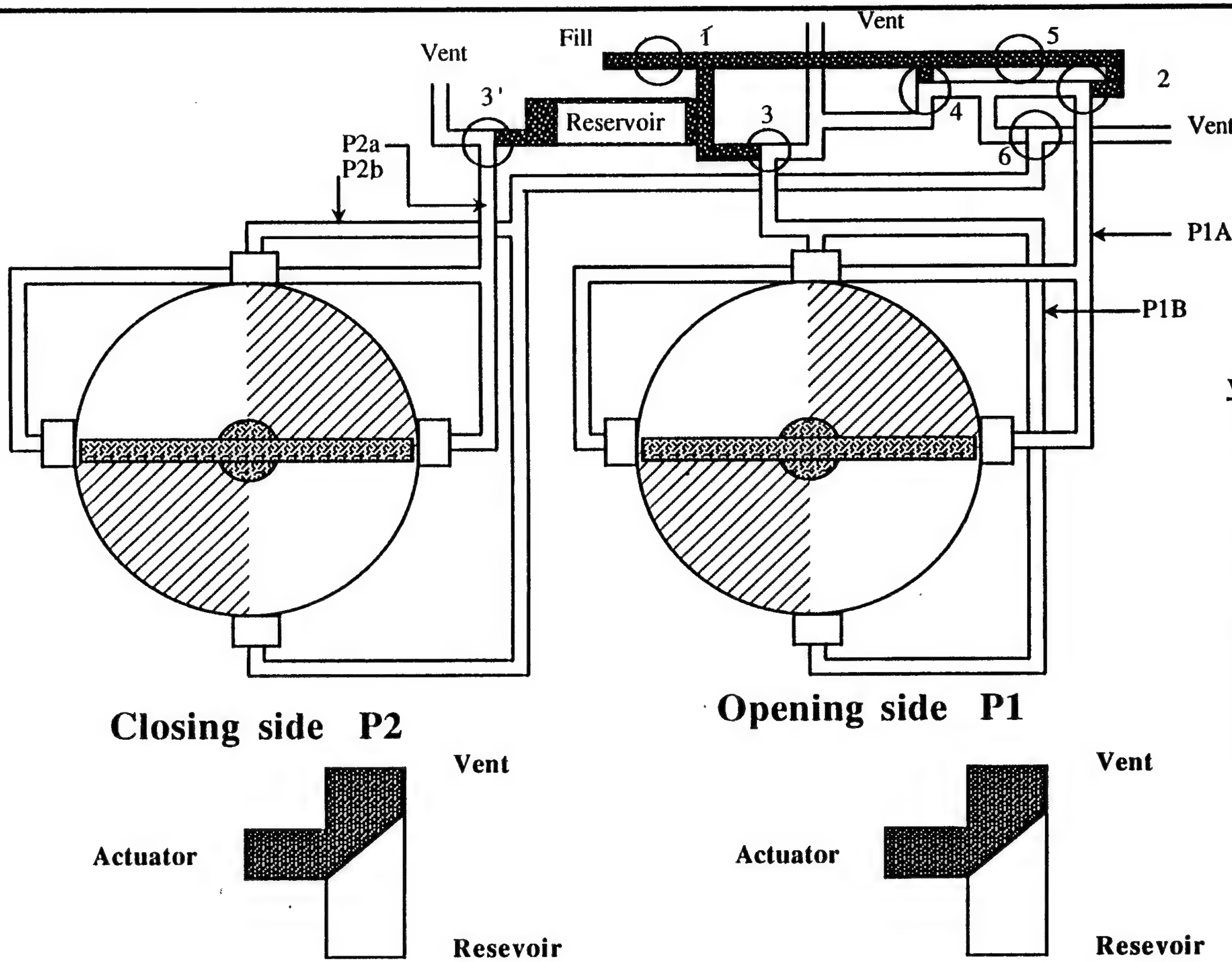
Valve	Status
1 (EV601)	C
2 (EV602)	D
3 (EV603)	D
3'(EV603')	D
4 (EV604)	V
5 (EV605)	O
6 (EV606)	V

D= De-Active
A= Active
C= Closed
O= Open
V = Vent
S = Supply

Neutral State (Off) No power to any valves
Main Valve Actuators are connected to vent



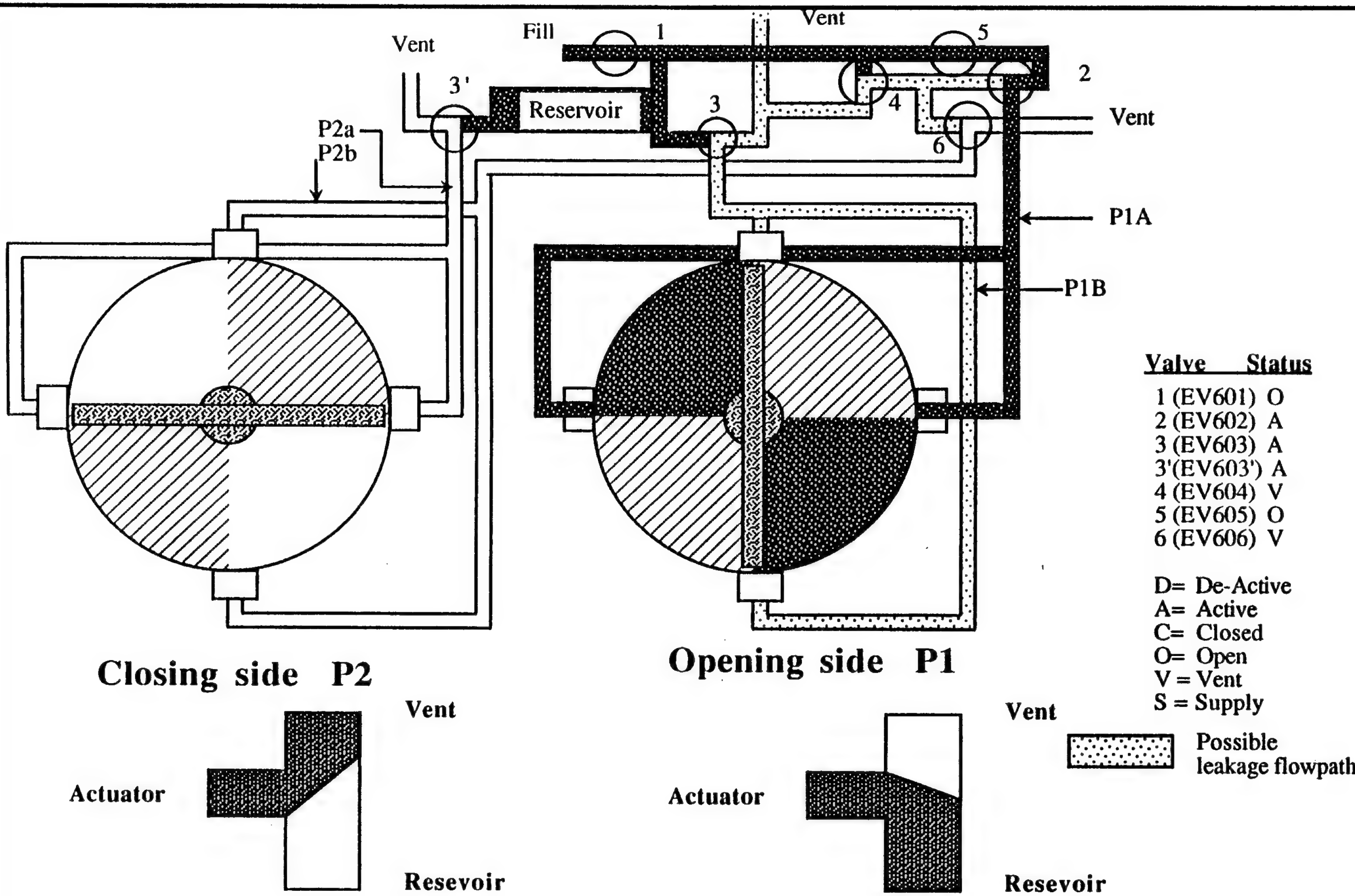
Step 1: Valves 3 and 3' are activated



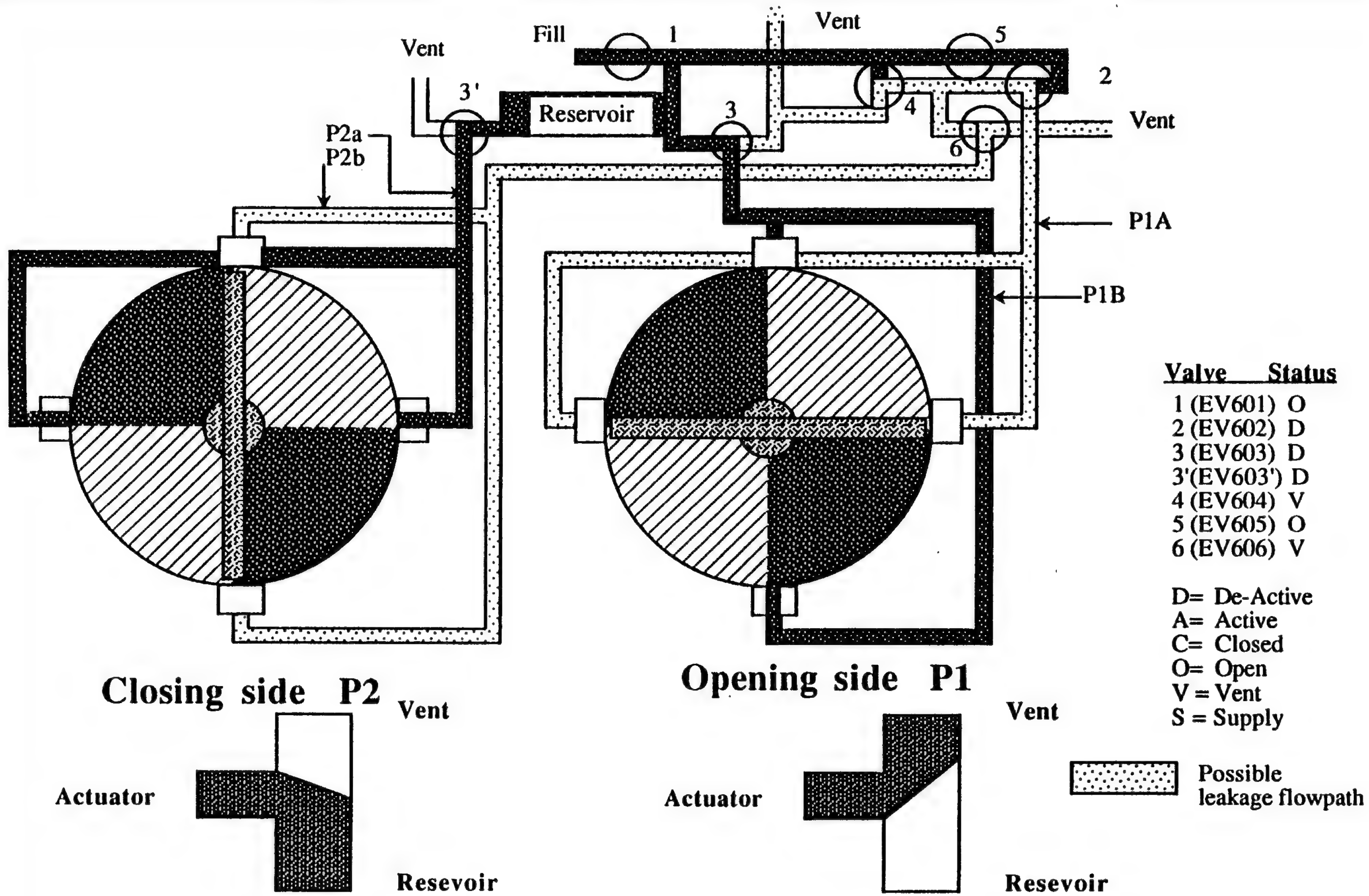
Valve	Status
1 (EV601)	O
2 (EV602)	D
3 (EV603)	A
3'(EV603')	A
4 (EV604)	V
5 (EV605)	O
6 (EV606)	V

D= De-Active
A= Active
C= Closed
O= Open
V = Vent
S = Supply

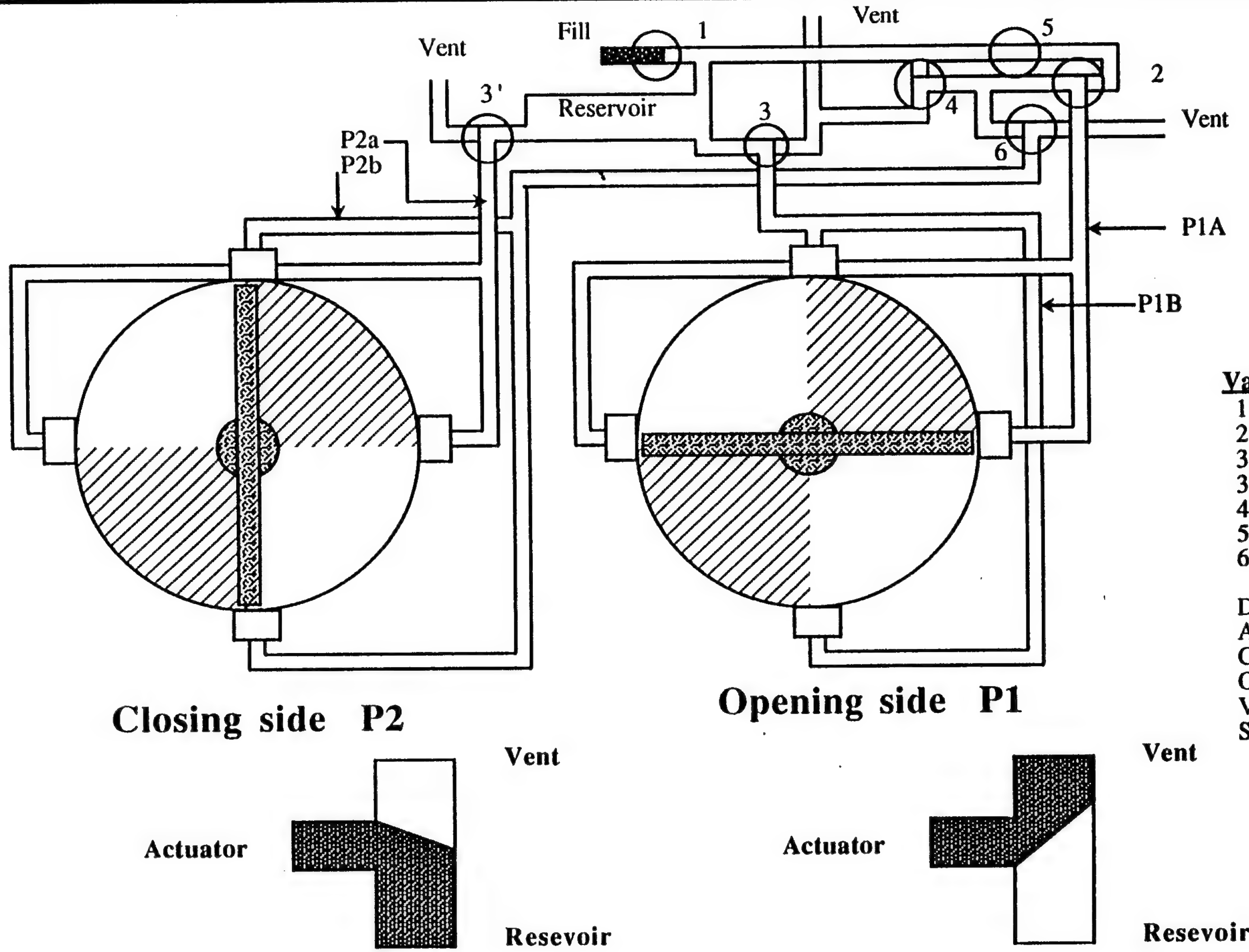
Step 2: Valve 1 is activated



Step 3: Valve 2 is activated
Test Begins



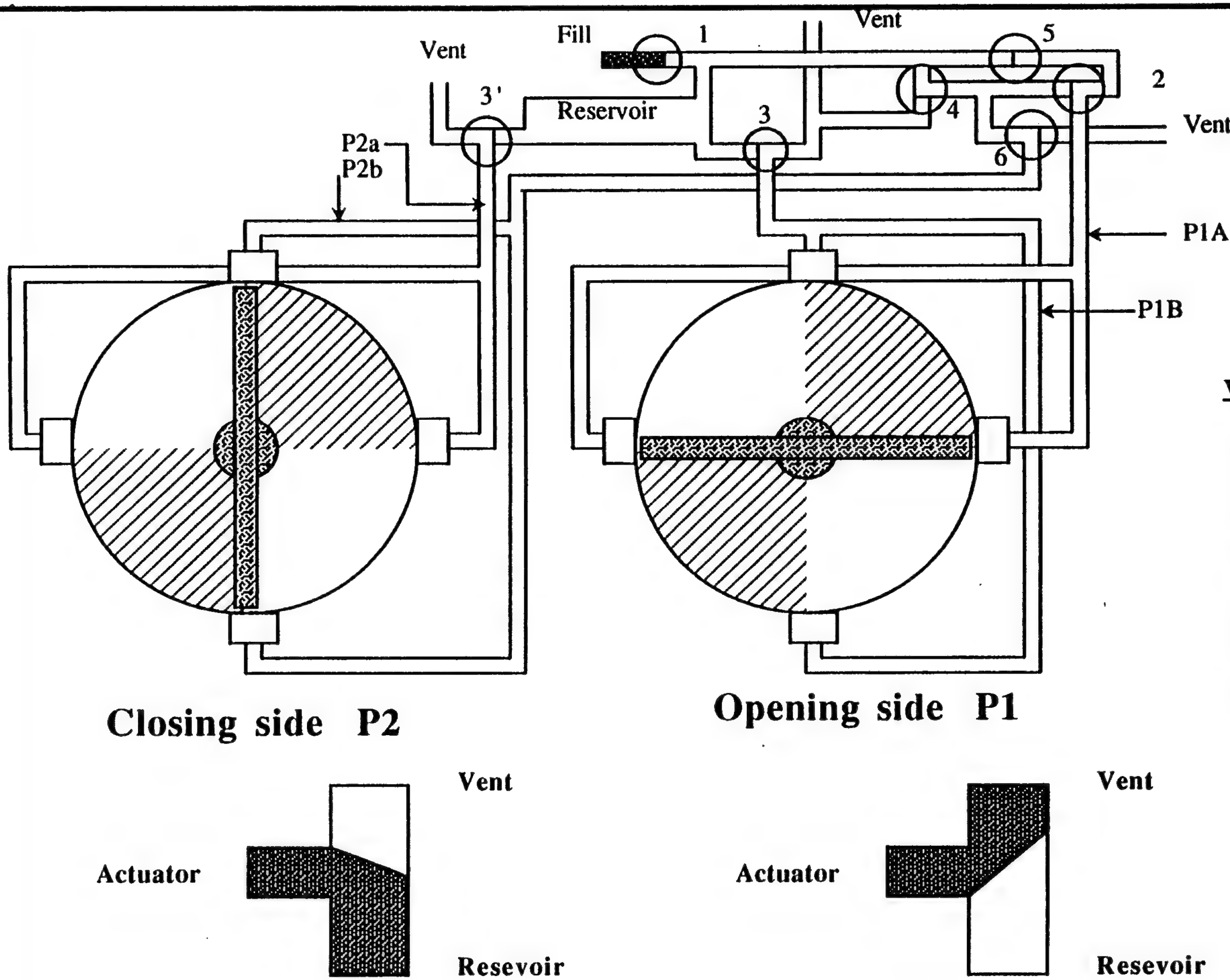
Step 4: Valve 2 and 3 de-activate Test Stops



Valve	Status
1 (EV601)	C
2 (EV602)	D
3 (EV603)	D
3'(EV603')	D
4 (EV604)	V
5 (EV605)	O
6 (EV606)	V

D= De-Active
A= Active
C= Closed
O= Open
V = Vent
S = Supply

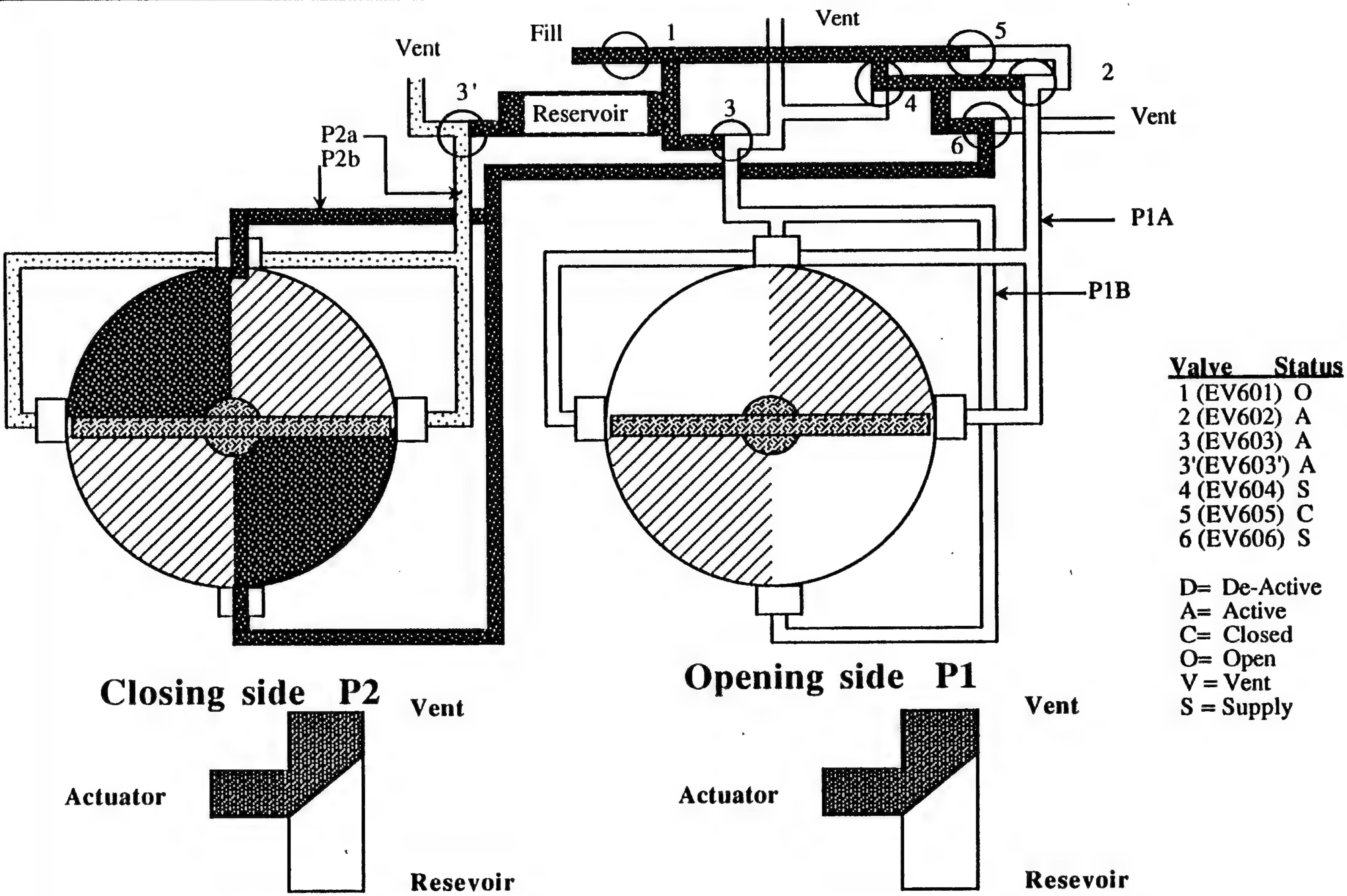
Step 5: When P1 and P2 stop moving (optics) Valve 1 closes (Stops Nitrogen) All Valves are Deactivated



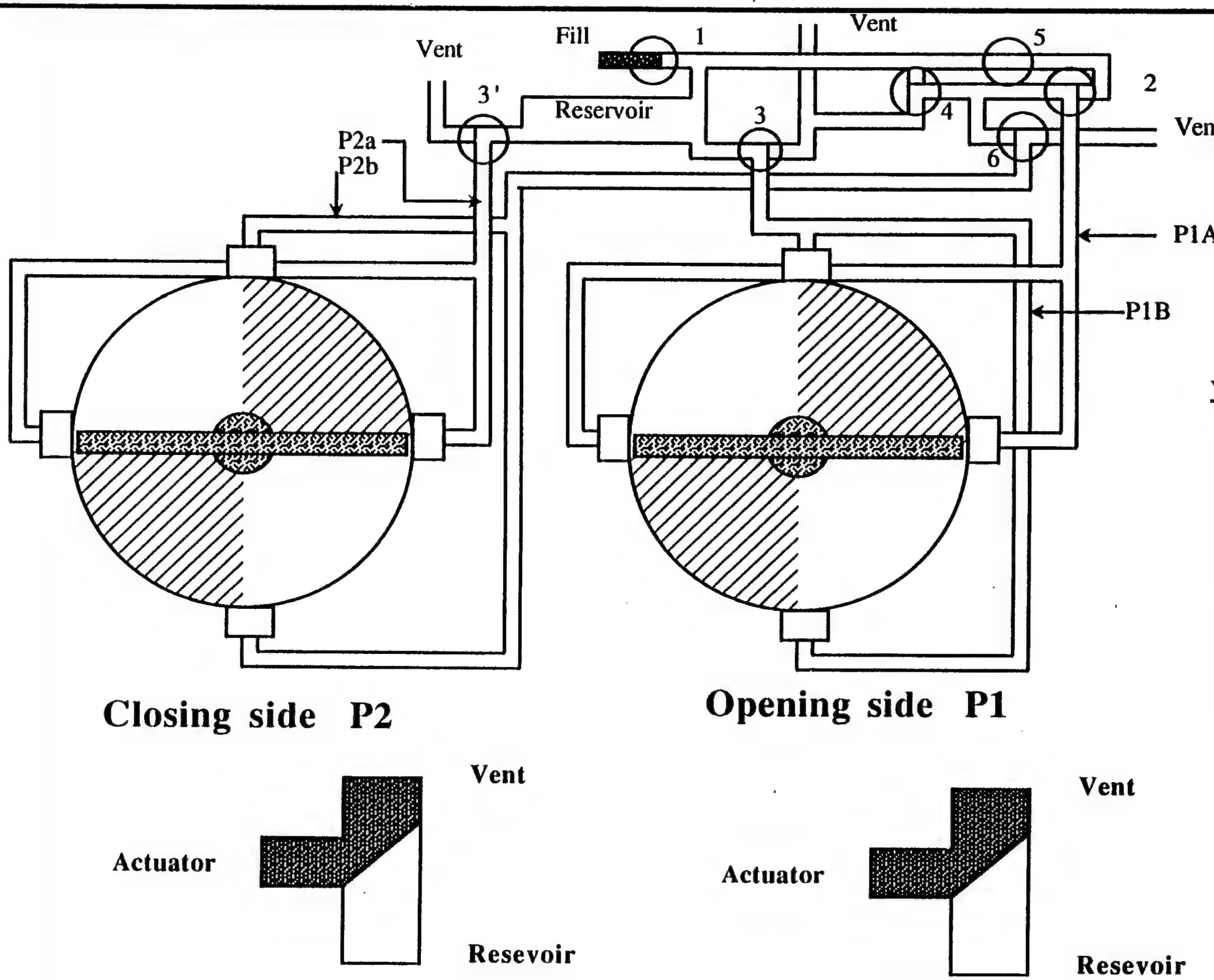
Valve	Status
1 (EV601)	C
2 (EV602)	A
3 (EV603)	A
3'(EV603')	A
4 (EV604)	S
5 (EV605)	C
6 (EV606)	S

D= De-Active
A= Active
C= Closed
O= Open
V = Vent
S = Supply

Step 6a: After Test, Start P2 Reset Process
Valve 5 closes,2, 3, and 3' activate, and 4 and 6 switch



Step 6b: [Reset P2], Activate Valve 1



Valve	Status
1 (EV601)	C
2 (EV602)	D
3 (EV603)	D
3'(EV603')	D
4 (EV604)	V
5 (EV605)	O
6 (EV606)	V

D= De-Active
A= Active
C= Closed
O= Open
V = Vent
S = Supply

Step 7: Deactivate all Valves

Simplified Electrical System

Drawing to be added by ATARR Faclility

Drawing to be added by ATARR Faclility

5. Checklists

This section contains some of the assembly checklists. Others such as the supply tank heating system, the agitator fan and cooling pump system should be added once these systems have been checked out. These could then be combined together to make a complete test checklist specific to the test matrix being used.

Isolation Valve (pgs. 39 - 40)

This covers both initial testing (by itself) and verification of operation before a turbine test.

Main Valve Activation (pgs. 41 - 44)

This covers both dry testing (with no piston supply gas), manual firing, the automatic firing of the system, and the procedures for placing the main valve into a total "safe" configuration. Extensive use of the main valve activation operation sheets (in Appendix II) are used as an aid.

Initial Evacuation (pg. 45)

This covers inspection, vacuum pump start-up, and proper operation verification.

Supply Tank Charging (pg. 46)

This covers inspection, and valve placement for charging the supply tank.

Eddy Brake (pg. 47)

This covers initial testing, inspection and set-up for final turbine testing

Test Checklist Non-Rotating Experiments (pg.48)

This is an example of how the previous checklists could be combined into a master checklist for a non-rotating, nitrogen only, experiment.

5.1 Isolation Valve Checklist

Notes:

This is the present procedure. The redesign of the isolation valve will undoubtedly change this.

Assumptions:

1) Isolation valve has been assembled and the choke area set correctly
2) Power to MCS and Genius Panels is on
3) The closing pistons and the turnbuckles are in the proper position
4) Instrument nitrogen reservoir is filled and the tube truck is on

Procedures:

Initial Inspection

1) Verify power connected to EV148 and EV132
2) Check for all plumbing connections: nitrogen in, nothing blocks vents
3) Determine initial valve position (open or closed)
4) Verify isolation valve housing is constrained from moving when the valve is moved
5) Close manual valve next to regulator PCV 130.
6) Verify access ports are bolted on

Dry Testing

1) Close manual valve next to regulator PCV 130.
2) Verify pressure in supply line is zero (PI 131)
3) Connect power to EV148 and EV132
4) Activate and deactivate EV132. Verify that EV132 changes position (can be done by listening to the valve click, it is loud)
5) Activate and deactivate EV148 (same as step 4)

Initial Valve Motion (no ΔP across valve)

1) Open manual valve next to PCV 130
2) Set PCV 130 to 10 psi
3) Open isolation valve (activate EV148), verify isolation valve opened
4) Activate EV132 (nothing should happen)
5) Close isolation valve (deactivate EV148), verify full valve closure. This must be done visually, a loud bang just means the valve has seated against something, it may not be closed.

Pre-test Preparation

1) Deactivate EV132
2) Set PCV 130 to 10 psi
3) Activate EV148 (verify isolation valve opened)
4) Set PCV 130 to 1.15 P_u (where P_u is the upstream pressure)

Note: These last two steps open the isolation valve and then increase the pressure to hold it open under the expected supply tank pressure load. If one were to increase the pressure on PCV 130 first, then activate EV148, one risks opening the isolation valve so hard that it breaks the stops.

Setting for Safe-Close Position

1) Set PCV130 to 10 psi
2) Deactivate EV148
3) Activate EV132, verify visually isolation valve is closed

Note: This configuration will remain closed as long as there is a positive pressure difference (going from test section to dump tank) across the isolation valve. Even if the power to EV132 were to fail (and thus it deactivates), this pressure difference holds the valve closed. If there is negative pressure across the valve, then the system can not be considered safe.

5.2 Main Valve Activation Checklist

Notes: Refer to accompanying activation drawings in section IV

Assumptions:

1) Two nitrogen bottles are connected to fill system
2) Power to MCS and Genius Panels is on
3) The main valve is initially closed
4) That the main valve control menu on the MCS is used to control the operation
5) Instrument nitrogen reservoir is filled and the tube truck is on

Procedures:

Initial Inspection (Done after assembly but before use)

1) Hoses for P1a, P1b, P2a, P2b, Reservoir supplies, and vents are connected properly
2) P1 and P2 indicators are set to vent
3) Nitrogen bottles tuned off
4) Regulators PCV 109 and PCV 107 off
5) Pressure in PI 108 = 0
6) Nitrogen supply to EV152 and EV151 is open
7) EV152, EV151 closed
8) Manual safety valves HCV 602, 603, 604 open
9) Verify all instrumentation ports are either closed or occupied

Operation of activation system only

1) Verify regulators PCV 109 and PCV 107 off
2) Verify EV152, EV151 closed
3) Verify Manual safety valves HCV 603, 604 open
4) Close manual safety valve HCV 602
5) Close needle valve HCV 601
6) Verify both P1 and P2 indicators are set to vent
7) Turn on nitrogen bottles
8) Set PCV 601 to approximately 200 psi
9) Set all valves to state shown in step 1

(Valve 601 closed, valve 602 deactive, valves 603 and 603' active, valves 604, 606 vented and valve 605 open) [MCS menu]

10) Open HCV 601 5 turns
11) Follow step 2 [MCS menu]
12) Set timer for main valve to close (usually two seconds) [MCS menu]
13) Start test [MCS menu]

Note: This basically starts step 3 and then after the set amount of time activates step 4. One can assure proper operation by checking that each of the actuator indicators (P1 and P2) have changed positions.

14) Follow step 5 [MCS menu]

15) Turn valve EV602 off

Note: The valve already is off, since EV603 and 603' are off. However, if these were to be reactivated before EV602 was turned off, it would reactivate. This is purely a function of the MCS control system and be capable of being changed so that it happens automatically.

16) Start P2 reset process. Either:

    A) Manually move P2 so that it reads vent

    B) Follow steps 6a, 6b, and 7

<u>Manual Firing of Valve</u> (this means not letting the MCS fire the system with the rotor spinning)

1) Verify regulators PCV 109 and PCV 107 off
2) Verify EV152, EV151 closed
3) Verify Manual safety valves HCV 602, 603, 604 closed
4) Verify both P1 and P2 indicators are set to vent
5) Verify EV601 closed
6) Verify N_2 instrument reservoir is pressurized
7) Turn on nitrogen bottles
8) Set all valves to state shown in step 1

    (Valve 601 closed, valve 602 deactive, valves 603 and 603' active, valves 604, 606 vented and valve 605 open) [MCS menu]

9) Set PCV 601 to approximately 200 psi
10) Set regulator PCV 109 to closing reservoir pressure, PCV 107 to open reservoir pressure
11) Open EV151 until open reservoir reaches desired pressure, close EV151
12) Open EV152 until closing reservoir reaches desired pressure, close EV152
13) Follow step 2 [MCS menu]
14) Set timer for main valve to close (usually two seconds) [MCS menu]
15) Start test [MCS menu]

Note: This basically starts step 3 and then after the set amount of time activates step 4. One can assure proper operation by checking that each of the actuator indicators (P1 and P2) have changed positions.

16) Follow step 5 [MCS menu]
17) Turn valve EV602 off

Note: The valve already is off, since EV603 and 603' are off. However, if these were to be reactivated before EV602 was turned off, it would reactivate. This is purely a function of the MCS control system and be capable of being changed so that it happens automatically.

18) Start P2 reset process. Verify that close reservoir pressure is 0. Either:

   A) Manually move P2 so that it reads vent

   B) Follow steps 6a, 6b, and 7

Automatic Firing of Valve (this means letting the MCS fire the system with the rotor spinning)

Not yet configured

Setting the main valve to completely safe mode

1) Shut of N_2 bottles
2) Open manual valves in following order HCV602, 604, 603

Note: The order is important. If for any reason there was pressure in the system, this allows one to maintain the closed position of the valve by venting first the activation reservoir (there should be nothing in it), then the open reservoir (which may have some residual pressure), and then finally the closing reservoir. If one were to invert the order, the open reservoir pressure could, if one accidentally moved P1 and P2, force the valve open.

3) Verify that both P1 and P2 are set to vent
4) If any of the following indicate pressure PI 108, PCV 109 or PCV 107 then

   A) Open cross-over ball valve between FV154 and FV153

   B) Open EV152

   Note: this allows any extra pressure in these lines to pass through the close reservoir and into the vents.

   C) Close ball valve

   D) Close EV152

5) If PCV 601 has pressure on it open EV601 until pressure is vented, then close EV601
6) Verify all pressure indicates on system read zero

Holding Valve Closed (useful for seating the main valve)

1) Verify regulators PCV 109 and PCV 107 off
2) Verify EV152, EV151 closed
3) Verify Manual safety valves HCV 602, 603, 604 closed
4) Verify both P1 and P2 indicators are set to vent
5) Verify EV601 closed
6) Verify N_2 instrument reservoir is pressurized
7) Turn on nitrogen bottles

8) Set all valves to state shown in step 1

(Valve 601 closed, valve 602 deactive, valves 603 and 603' active, valves 604, 606 vented and valve 605 open) [MCS menu]

9) Set PCV 601 to approximately 200 psi

10) Set regulator PCV 109 to 200-400 psi

11) Open EV152 until closing reservoir reaches desired pressure

12) Follow step 2 [MCS menu]

13) Manually shut-off EV603 and 603'

Note: This basically starts step 4 and and bypasses step 5. This keeps P1 in vent mode and changes P2 to supply, forcing the main valve closed. EV152 is kept open so that nitrogen is constantly supplied to the piston (which leaks)

14) Close EV601

15) Verify main valve is closed (listening for leaks or checking pressures)

16) Close EV152

18) Start P2 reset process. Verify that close reservoir pressure is 0. Either:

A) Manually move P2 so that it reads vent

B) Follow steps 6a, 6b, and 7

Initial Evacuation Checklist

Assumptions:

1) That the facility is bolted together
2) Power to MCS and Genius Panels is on
3) Instrument nitrogen reservoir is filled and the tube truck is on

Procedures:

Initial Inspection (Done before turning on pump)

1) Verify Cooling water to test section is hooked-up or that manual valve to test section is off
2) Verify all vacuum lines are in place
3) Verify all instrument ports or inspection ports are bolted down
4) Vacuum pump has oil

Starting Pump

1) Vacuum manifold is shut (EV317 is closed)
2) Cooling water is on, flapper valve open
3) Blower switch off
4) Manual instrument valve next to blower either off or isolated
4) MCS on and in pump down menu
6) Turn on pump
7) Verify that pump is working (by listening)

Evacuation of sections

1) Verify that all vents to section are closed and section is isolated
2) Open connecting valves to vacuum system
3) Observe outside vents (very little smoke should be coming out). If there is smoke, shut-down system and check filters
4) Once the final valve configuration has been reached, turn blower switch to automatic

Shut-down of vacuum pump

1) Shut-of pump
2) Vent vacuum side of pump to prevent vacuum oil from being drawn up and into the piping
3) Turn-off cooling water

Supply Tank Charging Checklist

Assumptions:

1) That the facility is bolted together, man-way closed
2) Power to MCS and Genius Panels is on
3) That the supply tank has been evacuated
4) Main valve is closed
5) Instrument nitrogen reservoir is filled and the tube truck is on

Procedures:

Initial Inspection (Done before turning on vacuum pump)

1) Verify all instrument ports are in place

Charging Supply Tanks

1) Go into MCS Charge menu, select gas, pressure level
2) Verify vents are closed
3) Verify all other systems are isolated (FV561 closed, EV126 closed, EV160 Closed)
4) Verify manual valve to supply tank is open
5) Select charge on menu

Note: As the rate of pressure increase in the supply tank starts to slow significantly, more tubes on the truck will need to be opened. Two tubes represent about 5 psi increase in tank pressure.

6) System will automatically shut-off when desired pressure is reached.

Eddy Brake Checklist

Notes: This will be added after the final check-out of the system

Test Checklist Non-Rotating Experiments

Assumptions:

1) That the facility is bolted together, man-way closed
2) Power to MCS and Genius Panels is on
3) That all systems have been check-ed out

Procedures:

Initial Inspection (Done before turning on vacuum pump)

1) Walk around facility check for tools on the facility, loose wires, loose bolts, trash, etc.
2) Check all piping connections

Perform:

3) Vacuum pump inspection
4) Main valve inspection
5) Tank charging inspection

Preparing Facility for Testing

Perform:

1) Vacuum pump start-up procedure
2) Dump tank evacuation procedure
3) Main valve closing procedure
4) Supply tank evacuation procedure

Note: for best results, always keep a positive pressure on the main valve to keep it from opening

5) When proper vacuum levels are reached stop supply tank evacuation (but continue dump tank and test section
6) Charge supply tank with nitrogen
7) Do final instrument check

Arming Facility and performing a test

1) Isolate and turn off vacuum pump

Perform:

2) Arm Isolation valve
3) Arm main valve
4) Fire main valve
5) Verify Main valve closed
6) Either prepare for another test by
   A) Venting dump tank and then re-evacuating dump tank and test section
   B) Recharging supply tank
7) Or move to safe condition by performing total system vent

Appendix I General Situations to Avoid

Throughout the initial testing of the ATARR, several facility problems which were not foreseen (such as the isolation valve and main valve leaks) have occurred which have lead to several "interesting" yet potentially dangerous testing conditions. These conditions are not part of normal ATARR operations. However, it is felt that those specific testing conditions should be discussed, especially the dangers inherent in them, so that no one proceeds with the idea "that since Calspan did one test this way it must be safe." Specifically several tests were done with the supply tank under pressure but the test section removed. As discussed earlier, to have the main valve open in this situation would require that both the main valve piston supply be charged, the main valve activation system be charge and the manual safety valves closed. However, having the test section installed (without a rotor) means that even if the main valve opened, the gas could only flow into the dump tank, not into the room.

Thus by operating with the test section removed, Calspan removed one of the multiple, redundant safety features. While there was no safety threat, it is clear that pressurizing the supply tank without the test section installed should not be a routine procedure.

Similarly, there may be a tendency between tests to take off an inspection plate while the supply tank is still pressurized and inspect the test-section. For obvious reasons this is a potentially dangerous situation and should only be done after the main valve has been place into its "safe" mode; and then only if it necessary.

There were also times when the isolation valve and test section were connected to the dump tank and evacuated, but the cooling section was removed. The potential in this case is to be evacuated into the test section if something went wrong. This was done to check the integrity of the isolation valve. This type of operation should only be done if the isolation valve has been placed in its "safe-close" mode and if there are no other ways to test the system.

There were also situations where both the isolation valve and main valve were tested dry (i.e with no pressure difference across them), while people watched the motion. Clearly, a safe distance should be maintained to avoid any potential problems.

In summary the situations to avoid are:

1) Pressurizing the facility without the entire test section installed
2) Working directly downstream of the supply tank when it is pressurized
3) Evacuating the facility without the entire test section installed
4) Working on the facility when parts of it are under vacuum

That does not mean that one can not undertake these tasks, rather that one should be aware of the increased risks.